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HARRY MARSHALL WARD

PHYTOPATHOLOGY

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HARRY MARSHALL WARD
(1854-1906)

E. M. FREEMAN

WITH PORTRAIT, PLATE I

While Americans are prone to look to Germany as the kind mother of the botanical sciences none will deny that England has contributed at least her fair share of able men and advanced ideas. Nehemiah Grew, Robert Brown, Sir William Hooker, Lindley and Charles Darwin are names that any nation would present with pardonable pride. But in the closing quarter of the last, and in the few past years of the present century botanical England has awakened to a new life, remarkably fruitful of men and research, until today her laboratories and schools command a most wholesome respect in all quarters of the globe.

Harry Marshall Ward was a factor of no small importance in this renaissance. England owes him a deep debt of gratitude, but the science of pathology also acknowledges his contributions not only of research but of the spirit and power which he imparted to the botanical movement.

To the average American the career of this little giant of pathology offers a fascinating story, particularly appealing to those who are more wont to associate such triumphs over natural difficulties with the greater latitudes of a youthful democracy rather than with a staid England. Ward's early career was fraught with difficulties, and his education and training were well and hard earned. Indomitable courage and an endless capacity for work made possible not only his early training, but constituted the basis of his future research. He apparently delighted in such stupendous tasks as the bacterial flora of the Thames, and dug deep into every nook and crevice of any field which he had started to explore. Thoroughness and detail he developed to a remarkable degree, stimulating and eminently sound in its effect on his own research as well as on that of his pupils, but inclining his presentation perhaps to undue length of description. In spite of such detail his teachings and numerous published works are marked by clearness and logical exposition. He combined with this love of detail an extraordinary breadth of knowledge and interest. No important field

of botanical research escaped him, and his powers of assimilation and correlation were astonishing.

Chance perhaps led him chiefly into the fields of pathology. His early work on the coffee rust of Ceylon seems to have given a permanent bent to his botanical career. From 1881, the time of his return from Ceylon, to 1888, Ward's contributions dealt with a large range of mycological subjects, including important results on the tubercle organisms of leguminous plants. He had previously studied with Sachs at Würzburg, and later with De Bary at Strasburg. These continental visits, while not extensive in time, were fruitful in inspiration and influence on his future work. In 1888 he published his paper On a Lily Disease in which he seems to have become fairly launched in what was probably the main problem of his life work, the problem of parasitism. His attention was naturally attracted to any association of plants in intimate relations of nutrition, and his paper on the Ginger Beer Plant opened the way to new conceptions of fungous nutrition. His problems of plant parasitism were now interrupted by that tremendous and almost appalling task the bacterial flora of the Thames, which work was at least remarkable for the wealth of laborious detail.

Upon his appointment to the chair of botany at Cambridge, in 1895, Ward took up again the question of parasitism and attacked the problems presented in the cereal rusts. While he was engaged in this work Eriksson startled the mycological world with his theory of mycoplasma. With characteristic keenness and thoroughness Ward subjected the mycoplasma theory to rigid laboratory and field tests. He was soon convinced of the fallacy of the theory and at once set about with his usual vigor to combat the hypothesis. While it is undoubtedly true that the controversy called forth productive research in many ways, yet it is to be regretted that the continuity of Ward's work was somewhat impaired by the controversial demands which were out of proportion to the value of the results. That his contentions in this controversy were well established few pathologists question.

Ward's last important work carried into further fields the problems of rust parasitism, especially with the brome rusts. His results, though far from satisfactorily completed as far as his own views were concerned, have been beacon lights of research along the most important road of the quest for the true meaning of parasitism, immunity and susceptibility.

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THE MIGRATION OF *BACILLUS AMYLOVORUS* IN THE HOST TISSUES

FREDA M. BACHMANN

WITH PLATES II AND III AND TWO TEXT FIGURES

SUMMARY OF PREVIOUS STUDIES

The little study which has been given to the migration of *Bacillus amylovorus* in the tissues of the host has resulted in quite different conclusions on the part of the several investigators who have taken up the subject. A knowledge of the exact manner of migration of the organisms is of equal interest to the horticulturist in its practical application to methods of pruning for the extermination of the disease, and to the general student of biological problems in the relation of the parasite to the cells of the host tissues. The problem was suggested to me by Prof. L. R. Jones under whose direction all of the work has been done. I wish to acknowledge my indebtedness to him for helpful criticism and suggestions throughout the progress of the work.

As is well known, *Bacillus amylovorus*, as the cause of blight in pear, quince and apple trees, was discovered by Burrill (2) in 1877. More recently it has been found to be the causal organism in the blight of plum (Jones, 4) and apricot (Paddock, 6). Burrill's conclusions concerning the relations of the organism to the tissues may be summarized as follows: the bacteria produce butyric fermentation of the stored carbonaceous compounds in the cells, especially in those of the bark outside the fibrous inner layer; the most conspicuous change in the tissues is the disappearance of stored starch; the cell walls are not dissolved or altered except the staining by oxygenized material in later stages of the disease; the protoplasm of young cells remains until death takes place; in older cells the thin protoplasmic lining of cell walls can be seen after the starch has disappeared; bacteria swarm in cells absolutely closed, with no observable corroding of the cellulose wall whatever. To account for the entrance of bacteria into such closed cells, Burrill suggested that, if we accept Nägeli's theory of molecular construction of the cell wall, the bacteria may be so plastic that, like amoebae, they may creep through the spaces between the molecules, or in case they are smaller than the molecular openings they may pass through these from cell to cell. Burrill further observed that in very young tissues all parts except the epidermis are equally affected,

but in older limbs the chlorophyll-bearing parenchyma of the bark is the first and usually the chief seat of the disease, the bast is not affected and the cambium may retain its vitality when all outside has perished, the xylem may be stained by the ascending water colored in its upward passage through the dying and brown parts.

By using the sterile filtrate of a strong solution of blighted tissue for inoculating green pears, Arthur (1) found in 1885 that the disease was produced by the organisms and not by their products.

In 1895 Waite (9) records that the inner bark and cambium layers are killed but that the bacteria rarely kill the leaves, only occasionally attacking the stems and midribs. The leaves die after the branch is killed. As to the rate of progress of the disease, Waite found that in one day it rarely extends farther than 2 or 3 inches from the point of attack, but occasionally travels as much as 1 foot. Warm moist weather with frequent showers favor blight while cool sunny dry weather hinders it and very dry weather may check it entirely. In old dried bark where the disease has stopped the bacteria have all died and disappeared.

Whetzel and Stewart (10) state that the bacteria do not travel through the sap tubes but slowly work their way through and between the cells of the bark. Shortly after the publication of their observations, D. H. Jones (5) published a bulletin in which quite different views are held. He figures the diseased pedicel of a young apple in which he says the cells are "surcharged with *B. amylovorus*." He also finds the cells of apple fruit filled with bacteria. He states that "the bacillus lives in the cells of the inner bark, feeds on the cell contents and, as it develops and multiplies, passes along from cell to cell, destroying the tissue as it progresses. It may travel down the twig at the rate of from 0.25 inch to 2 inches a day."

In view of these diverse opinions, it seemed worth while to make a careful examination into the histological relations of host and parasite. In my studies I have inoculated blossoms of pear, water-shoots of apple, young pear seedlings, young shoots of pear and plum and fruits of pear and apple.

INOCULATIONS OF PEAR FLOWERS

Pear flowers were inoculated by placing a drop of a bouillon culture of *B. amylovorus*, in the outer calyx cup. As is well known, it is not necessary to make any mechanical injury to secure infection, for the bacteria readily gain entrance into the tissues through the nectary. The infected calyx cup and pedicel of the flowers were later fixed in various fixing fluids, by far the best results being obtained with picro-formol. Normal tissue for comparison was fixed in exactly the same way at the same time. Sections were cut 10 microns thick.

In these sections there can be no doubt at all as to the path of migration of the bacteria. The cells are not so large but that much of each cell is seen in the section. The walls are very thin and the intercellular spaces large. The slimy cytoplasm forms a thin, peripheral somewhat granular layer. The granules in the cytoplasm are so very minute that it is not possible to confuse them with microorganisms. In inoculated tissue the intercellular spaces contain few to many bacteria (text fig. 1).

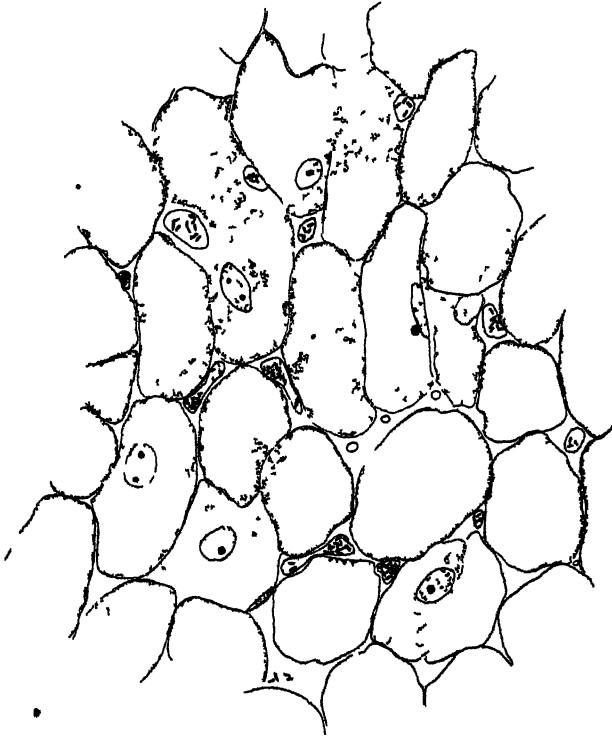


FIG. 1. Cross section of pedicel of inoculated pear flower showing bacteria surrounded by film of liquid in the intercellular spaces. $\times 580$

Bacteria may be found in at least one-half of the intercellular spaces at a time when the cell contents are in no way disorganized. There may be at this time some indication of plasmolysis but the slimy layer of cytoplasm is still next to the cell wall and the only difference between these cells and those of the normal tissue is that they are less turgid.

The bacteria are surrounded by a film of liquid which it seems likely has been drawn out from the cell sap. In the parenchymatous tissue they are never found within the cells in early stages of infection and cer-

tainly migrate entirely between the cells. In somewhat later stages of infection there are sometimes broken places in the cell walls, but no tendency as yet for the bacteria to enter the cells. It is possible that these broken places are the result of a chemical dissolution of the cell wall by substances secreted by the bacteria. However, we should then expect the wall gradually to become thinner until large openings resulted, but this is not the case. The appearance of these torn places suggests, rather, that the break is due to a mechanical rupture. It is not impossible that some chemical dissolution may first weaken the wall, which is then easily torn. Even when the tissue has become much shrunk and the cells distorted the bacteria are found, with few exceptions, only in the intercellular spaces. Here they are often crowded so that the group stains very deeply. In very late stages of infection the cells are completely plasmolyzed and the walls more or less broken. The dead tissue occurs in masses with large open spaces between. These masses contain many bacteria. Often, when the broken cell wall is not collapsed, the bacteria fill the space within. The protoplast in every case becomes so much plasmolyzed that it forms a dense, often quite homogeneous, mass. I have observed no tendency for the bacteria to invade the protoplast and it is very evident that they are not found abundantly in any of the cells before the death of the latter.

INOCULATION OF SHOOTS OF APPLE, PEAR AND PLUM

For this study water shoots of apple, seedling pears or young shoots of apple not over 3 inches long and young shoots of plum were used. The inoculations of pear and plum were made on greenhouse plants. In the case of apple, the water shoots were brought into the house, inoculated and then placed in a damp chamber. The same method of inoculation was used throughout, viz:—a drop of a bouillon culture of *B. amylovorus* was placed on the side of the stem from one to a few inches* from the tip of the shoot and then by means of a sterile needle the epidermis was ruptured within the drop. Picro-formol gave the best results as a fixing fluid. Normal tissue for comparison was always fixed at the same time. Most of these sections were also cut about 10 microns thick.

In unstained hand sections of living shoots after inoculation I have found that a plasmolysis of the cells of the cortex, and to some extent of the pith cells, is one of the first indications of disease resulting from the bacterial invasion. In stained sections it is evident that the large intercellular spaces of the cortex provide a ready path for the migration of the organisms. These spaces, which are frequently as large as the cells, are often seen packed with bacteria (pl. II, fig. 2). Indeed it is

not impossible to mistake these large spaces so filled with deeply staining bacteria for cells, if care is not taken in focusing. In early stages of infection in apple shoots I have found many of these spaces crowded with bacteria when the cells were only partially plasmolyzed and the cell walls seldom broken. The organisms migrate just as readily between the cells of the pith (pl. II, fig. 1) but, since I have sometimes found the pith quite or entirely free of bacteria when all the other parts are infected, I am inclined to think that the organisms do not readily gain entrance to this region unless the wound made by inoculation has extended through the bundle ring. Later, the walls of the cells of cortex and pith sometimes become broken in places so that bacteria may enter the cells. Frequently some of the cell walls are broken and the surrounding ones collapsed so that large open spaces more or less filled with bacteria result.

I have found that the bacteria enter the xylem tubes very readily (pl. III, figs. 1-3). These tubes, in some places in a shoot, are so packed with the organisms that the transmission of sap in such a region seems quite impossible. In a plum shoot inoculated about 5 inches from the tip many of the xylem vessels 3 inches above the point of inoculation were filled with bacteria. Sections only about 1.5 inches above the point of inoculation seem to show fewer bacteria in the vessels. This would suggest that the bacteria entered the xylem some distance above the point of inoculation and then migrated downward in these tubes. The same phenomenon was observed in a seedling pear about 3 inches in height. This was killed and fixed eight days after inoculation. The xylem tubes were found free of bacteria except near the apex of the shoot where in some of the tubes bacteria were in abundance. In another young seedling pear of only 2 inches, also fixed eight days after inoculation, where the point of inoculation was about in the middle of the stem, the xylem tubes both in the upper and lower part of the shoot were full of bacteria. In such exceedingly tender tissues as those of very young pear seedlings it may be that the organisms can penetrate the xylem tubes at any place. However, it is not impossible that here too the organisms may work downward in the stem. Oddly enough some xylem tubes may be filled with the organisms while the adjoining ones are entirely free. Longitudinal sections show this especially well. The parenchyma cells between the xylem tubes are densely filled with granular cytoplasm and are usually entirely free of bacteria. There is apparently no tendency for the organisms to enter these cells.

It is probable that the bacteria in some way destroy or break through the thinner parts of the walls of the tracheids. The thin-walled cells between the xylem become completely plasmolyzed and partially disintegrated so that large open spaces in the xylem are formed (pl. III, fig. 1).

The xylem tubes often appear as loose partly uncoiled spirals (pl. III, fig. 2). When all the xylem elements are filled with bacteria, or completely destroyed, the cambium cells may to all appearances be normal. But these, too, may be destroyed later. By the time the tissues appear blackened the cells are completely plasmolyzed and apparently dead. The petioles of leaves and stems which appear to be in a perfectly healthy condition have been found to be invaded throughout by the organisms. An inoculated seedling pear showed only a narrow streak of blackening on the edge of the stem on the upper two-thirds of the shoot and at the bases of the leaf petioles. The leaves gave no evidence of wilting. When this seedling was sectioned the xylem tubes were found to be full of bacteria in the upper part of the plant; the intercellular spaces of pith and cortex contained many bacteria and in some places the cells were destroyed, leaving relatively large cavities filled with bacteria. A leaf petiole which showed a few bacteria in the xylem and in which the parenchyma cells were badly plasmolyzed, when traced to its origin was found to come from a region where the xylem tubes were completely plugged by the organisms and where many of the cell walls were broken. The cells in the apical region of this seedling were found to be entirely normal while, only a few sections from the tip, bacteria were abundant in the intercellular spaces. Farther away from the tip occasional large areas in the pith had been destroyed. It is very evident from this series of sections that the primary path of the migration of the organisms has been through the intercellular spaces and that the xylem tubes were invaded later.

INOCULATION OF FRUITS

For this work green hard Bartlett pears and Whitney Crab apples were used. The pears were from 1.5 to 2.5 inches long and the apples about 1.5 inches in diameter. The calyx end of the fruit was cut three-fourths across with a sterile knife in the manner indicated in the diagram (text fig. 2) so that a part remained attached. Then with a sterile platinum loop bacteria were transferred from a pure agar or bouillon culture of *Bacillus amylovorus* and smeared over the cut surface. The exudate which appears on old infected fruits was also used for inoculation. The upper portion of the fruit was then pressed rather firmly down so that there would be as little exposure to drying as possible. The entire fruit was then placed in a covered jelly tumbler containing just enough water to submerge the end of the stem. The inoculated fruits were either kept at room temperature or in the refrigerator. The fruits were observed from day to day and results noted as to the production of exudate or as to rotting. A softening of the tissues, with accompanying transparency,

is what I have called fairly well rotted. The exudate appeared first on the cut surface of the fruit and later was exuded in beads on the entire outer surface. The first evidences of rotting showed as quickly in the apples as in the pears.

Small pieces of both inoculated and normal apple and pear were fixed in picro-formol, Merkel's fluid or Flemming's strong solution of chromosmic-acetic acids. Not all of the material has been sectioned but satisfactory results were obtained with both the Merkel and Flemming mixtures. The cells of these green fruits are quite large so that it was found necessary to cut the sections rather thick, preferably about 20μ . *B. amylovorus* stains fairly well with the triple stain but much more readily and more sharply with carbol fuchsin. The latter, either alone or combined with gentian violet and orange G, has also given very good results

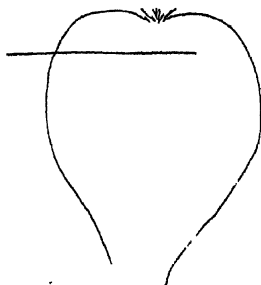


FIG. 2. Diagram showing how fruits of apple and pear were cut for inoculation.

in staining the structures of the normal cell. For this reason I have preferred the use of carbol fuchsin instead of safranin.

The great bulk of tissue of these fruits consists of large, very irregular parenchyma cells with abundant intercellular spaces. The cell walls are quite thin but stain deep pink with carbol fuchsin or blue with gentian violet. These parenchyma cells have very large central vacuoles with a thin peripheral, somewhat granular cytoplasmic layer within which is the nucleus, usually flattened somewhat against the cell wall. The nuclei are easily stained and contain one or more deeply staining nucleoles and chromatin distributed throughout in a finely granular condition. This description serves for that parenchyma which composes at least the greater part of the calyx cup. The parenchyma cells which are nearer the center of the fruit contain a great number of granular microsomes which vary somewhat in size. Some of the smaller ones might easily be mistaken for bacteria, the more so since they stain as deeply, as a rule, as do the

bacterial cells. The starch grains which are scattered about in the cells vary in size but they are usually many times larger than the small granules I have described. The parenchyma cells containing these masses of granules are nearer the center of the fruit, and hence near the fibro-vascular tissues. Bunches of sclerenchyma cells are found scattered throughout the pear tissues.

In some cases I have fixed thin longitudinal slices through a half of the fruit so that it is entirely possible to trace the bacteria from the point of inoculation and also to observe all stages of disintegration of the tissues. In the longitudinal sections of pear the well-rotted tissue near the inoculated surface is stained a deeper red than the remaining tissue. This is due to the fact that the cells have lost all turgidity and are for the most part almost entirely collapsed. The content of the cells occurs in irregular masses, very dense in some places, and occasionally granular. It is not possible to say that in a cell which contains a great deal of finely granular material there are absolutely no bacteria at all, but the more I have studied my preparations the more inclined I am to doubt that the bacteria enter these cells to any great extent, if at all.

On the other hand, bacteria may often be found between the cells and on the outer surfaces of some of the cell walls. It might at first appear that the organisms are imbedded in the red-staining material within the cell, but this is easily disproved by the many cross sections of cells which never show the bacteria inside the cells. Frequently, they lie so close to the cell wall that it appears as if they might be at least partially imbedded in it. In even this well-rotted area the walls are for the most part unbroken, although occasionally they are torn. It may be possible that this tearing is at least partially due to sectioning, since in the pear the masses of sclerenchyma tend to tear away from the other tissue. In a few cases I have thought it possible that a few organisms may have entered cells where the walls are torn, but I am very certain that the cells in this much-rotted tissue are at least not packed full of bacteria. My preparations are from tissue which had been inoculated from six to ten days. It may be that in fruits which have been inoculated a much longer time bacteria would be found within the cells. But, in this connection, I have observed that there are fewer organisms in the well-rotted parts than in those parts which show very little or no rotting. In these less-rotted regions the location of the bacteria is the same. Here the cells are less collapsed and the intercellular spaces are larger. These spaces are filled with bacteria (pl. II, fig. 4). In parts of the section still further away from the point of inoculation the cells are more turgid and the bacteria less plentiful and, again, they are only in the intercellular spaces. Pears 2 inches long kept in the ice chest for six days after

inoculation showed at this time bacteria scattered throughout the fruit in the intercellular spaces.

In the inoculated apple fruits which I have sectioned rotting had not progressed to any extent beyond the inoculated surface and organisms were found only very near this surface. However, here too, the path of migration appears to be the same as that in the pear, since I find the bacteria only between the cells and not within them. Those cells which are exactly on the inoculated surface of the section, and which were doubtless torn in cutting the fruit for inoculation, contain bacteria, but besides this I find no bacteria within the cells in these early stages of rotting.

As to the migration of the organisms in green fruits of pear and apple, I conclude that the path of migration is through the intercellular spaces from the region of inoculation to all parts of the fruit. They apparently extract the cell sap from the cells thus causing the death of the latter. Toxic substances, if produced, probably do not precede the advance of the bacteria, since bacteria are found between apparently normal cells. I can find no evidence at all in my sections of pear and apple that the bacteria progress from cell to cell.

CONCLUSIONS

The first evidence of infection in the tissues of fruit or shoot is a transparency around the point of inoculation, followed later by a browning in the same region. From my studies I conclude that this transparency is due to the removal of air from the intercellular spaces, this being replaced by the liquid in which the bacteria live. Doubtless this liquid is cell sap which has been extracted from the cells, thus causing them to lose their turgidity. The cells die, apparently because of a loss of water, although chemical changes in the protoplast may accompany this loss. The substances produced in the metabolism of the organisms are, judging from the microscopic evidence, not at all strongly or quickly toxic in their effect on the cells. This is evident because the organisms are found abundantly between cells which to all appearance are entirely normal. The film of liquid in which the bacteria move is not extracted in such amount that it precedes the bacteria to any extent. My conclusions on the non-toxicity of the bacterial products on the cells of the host are in agreement with some experiments of Arthur (1) who found that solutions in which the organisms were grown, when filtered and placed in green fruits, resulted in no rotting at all. It seems to me that at least all of the first changes in the cells which result from infection may be attributed wholly to a loss of water. However, it is possible that the disintegration of the tissues may result in poisonous products which later hasten the death of other

cells. The relations of the bacteria to the host is much like that of the rust *Uromyces pisi* to its host *Euphorbia cyparissias*. Tischler (8) found that the mycelium here never enters cells which are full of protoplasm such as those in the growing regions but readily sends haustoria into those cells which have become vacuolated. The mycelium grows between and among the cells and in the xylem tubes. Here too, as I have found, some of the xylem tubes are full of mycelium while others adjoining are entirely free from it. Another point of likeness is that the mycelium in the older infected parts is dead and that it lives only near the growing regions.

As to the rate at which the bacteria may migrate I have no data. Water-shoots of apple forty-eight hours after inoculation were fixed and when sectioned the organisms were found one-half inch from the point of inoculation. At this time there was only a slight transparency around the wound. I have repeatedly found that tissues which are to all appearances healthy contain many bacteria in the intercellular spaces.

Burrill (3) concluded that the bacteria feed on the carbonaceous material in the cells. In the cells of pear fruits there appears to be somewhat less granular material in the tissues which are diseased. In apple I have not observed a diminution in the amount of starch in the cells. The cellulose walls are not digested early, although it seems that digestion in some portions of the walls may have occurred to cause the broken places. If there is a process of cellulose digestion it certainly goes on very slowly and not uniformly over all surfaces. However, since the bacteria are most abundant in the intercellular spaces it is possible that we have here the result of what Smith (7) terms a mass action of bacteria, i.e., a result which can only be brought about by a large number of organisms. It seems possible to explain the broken walls on a purely physical basis. There is certainly a very great pressure exerted to cause the exudation of so much slime on the surface of the twigs. The cortical cells of the bark are very close together and some force must be exerted to cause them to tear apart. It may be that the osmotic pressure of the substance in which the bacteria are found is sufficiently great to rupture the cell walls. Evidence of such pressure is found in the large cavities which are formed in the xylem, cortex or pith. These cavities are frequently rounded or oval and suggest an equal pressure in all directions. The result of a process of enzymic solution should be the gradual dissolution of the entire wall and not merely a tear at one place. There probably is such digestion of the walls to some extent but osmotic pressure is, in our judgment, a more important factor in their final rupture.

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EXPLANATION OF PLATES

(All figures were drawn with the aid of a camera lucida)

PLATE II

FIG. 1. Longitudinal section of pith from inoculated shoot of apple showing organisms between the cells. $\times 750$

FIG. 2. Transverse section of cortex from inoculated shoot of apple, showing cells plasmolyzed and organisms for the most part between the cells. $\times 450$.

FIG. 3. Surface view of cortical cell walls from apple shoot, showing organisms on the outer surface of the walls but not in the cells. Some of the walls ruptured. Breaking of walls probably due to great osmotic pressure. $\times 750$.

FIG. 4. Section through inoculated pear fruit. Cells plasmolyzed and organisms in intercellular spaces. $\times 450$.

PLATE III

FIG. 1. Cross section of inoculated apple shoot, showing organisms in the xylem tubes, large cavity found in xylem and pith cells plasmolyzed. $\times 750$.

FIG. 2. Same as figure 1. Part of the walls of xylem tubes destroyed. $\times 750$

FIG. 3. Cross section of inoculated apple shoot showing earlier stages of infection than figures 1 and 2. Organism in the xylem tubes and to all appearance between the thicker parts of the wall. $\times 750$.

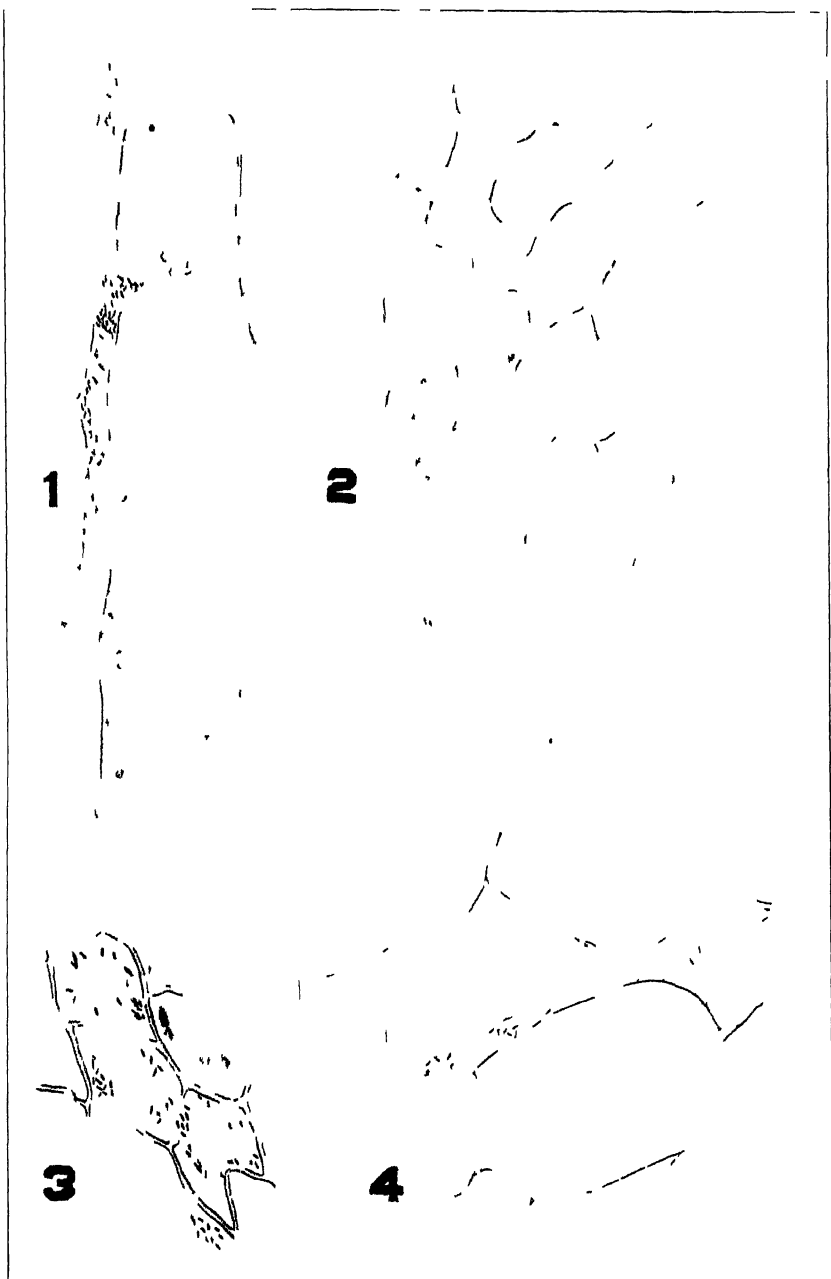


PLATE II — *BACILLUS AMYLOVORUS*

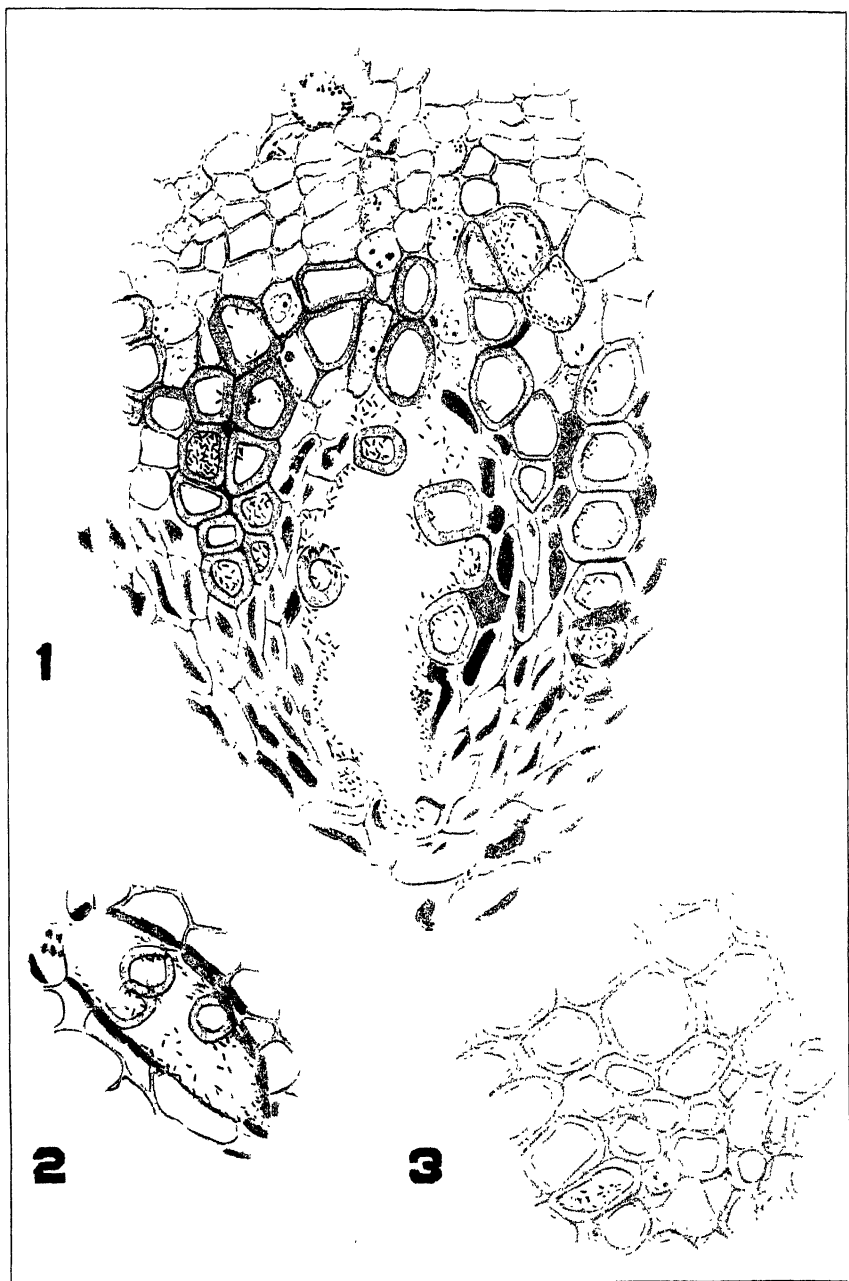


PLATE III.—BACILLUS AMYLOVORUS

NOTES ON SOME WESTERN UREDINEAE WHICH ATTACK FOREST TREES. II¹

GEORGE GRANT HEDGCOCK

The following paper is a continuation of notes on observations made on field trips in the west by the writer.

1. PERIDERMIIUM FILAMENTOSUM Peck

This fungus, in an overmature condition, was found in abundance on a number of trees of *Pinus ponderosa* Laws. near Rollinsville, Colorado, August, 1912. Plants of Castilleja in the immediate vicinity were badly injured by its alternate stage, *Cronartium filamentosum* (Peck) Hedgc.² No other species of Peridermium was found in the vicinity.

On September 5, 1912, a number of trees of the same species were found diseased with this Peridermium in the forest on the Fremont Experiment Station of the Forest Service on Pikes Peak, Colorado. Most of these were badly diseased and decadent, although they were young trees not over fifty years of age. In one instance freshly-fruiting aecia of the fungus were found. This is unusual, for the fungus, as a rule, fruits during the latter part of June and the first of July. As at Rollinsville, the Castilleja plants in the immediate vicinity were badly diseased with *Cronartium filamentosum*. No *Peridermium harknessii* Moore was found in this locality.

It might be well at this point to state that *Peridermium filamentosum* is the most destructive species of Peridermium that has been observed in the west. The first time it fruits abundantly it apparently kills the limb affected, due to the drying out of the tissues ruptured by the large aecia. On the one hand, this feature tends to limit the ravages of the fungus, since the fungus itself is thereby killed, but this is offset, on the other hand, by the fact that the fungus is apparently able to grow along the cambial layer from one twig or limb around a fork into another, thus spreading the disease without reinoculation.

Where close grazing by cattle or sheep occurs, which is now usual in western forests, the Castilleja plants are browsed so closely that little

¹ Published by permission of the Secretary of Agriculture. The first paper was read at the 1911 session of the Phytopathological Society in Washington, and published in *Mycologia* 4: 141-147. May, 1912.

² See *Phytopathology* 2: 176-177. 1912.

or no *Cronartium filamentosum* is found and the spread of the fungus is held in check. This is fortunate, indeed, and so long as this condition exists, little is to be feared from this rust in closely grazed forests.

2. PERIDERMIIUM HARKNESSII MOORE

This species of *Peridermium* was not found in abundance in any locality visited this year. No good evidence has been found to support the assumption made in my previous paper that this fungus may have a telial form in a *Coleosporium* on asters, and it is doubtful if such be the case. In California, on the Monterey peninsula, Dr. E. P. Meinecke of this office found last spring a species of *Cronartium* on *Quercus agrifolia* Née in direct proximity with the galls of *Peridermium harknessii* occurring on the Monterey pines (*Pinus radiata* Don). No other gall-forming *Peridermium* was found on the peninsula. This *Cronartium* is morphologically identical with *Cronartium quercuum* (Brond.) Schr. For three successive years attempts have been made in the forest pathological greenhouse at Washington to successfully inoculate the leaves of eastern oaks with the aeciospores of *Peridermium harknessii*, without success. This, however, is negative evidence, and it may be that the spores used in the inoculations had lost their vitality during the period required for their shipment from the far west to Washington. No attempt has been made, to my knowledge, to artificially inoculate *Quercus agrifolia* with *Cronartium quercuum* in its eastern form. From this it appears that *Peridermium harknessii* Moore and *Peridermium cerebrum* Peck may be synonymous, since the type material of the former was collected on *Pinus radiata* in California on the Monterey peninsula. If such be the case, the other forms of *Peridermium harknessii* occurring on other species of pines in the west where no oaks are found, are either new species, or *Cronartium quercuum* in its western form must occur on some other hosts beside the oaks.

3. PERIDERMIIUM MONTANUM Arth. & Kern

This year no extensive search was made for this species of *Peridermium* on the lodgepole pine (*Pinus contorta* Loud.). In 1911 it was collected in abundance in June on the lodgepole pine by Forest Ranger George, and later in the season by the writer, in the Gallatin National Forest, south of Bozeman, Montana. A search this year by Mr. George was made in the same localities. He was unable to find either the *Peridermium* on the lodgepole pines or the attendant *Coleosporium* found by the writer so abundantly on asters in proximity to the diseased trees. In other portions of the same forest this year, however, a species of *Coleo-*

sporium occurred sparsely on the leaves of wild asters and it is possible that the heavy infections of pines may occur infrequently.

4. *PERIDERMUM COLORADENSE* (Dietel) Arth. & Kern

A number of national forests were visited in Colorado this year in which both *Picea engelmanni* Eng. and *Picea parryana* (André) Parry occur. The latter species grows as a rule at a lower altitude and was found more commonly attacked by *Peridermium coloradense* than the former. Many trees diseased by this fungus were noted, especially in the Rouett, Arapahoe, and San Isabel national forests in Colorado and in the Manti national forest, Utah. A large number of these were in a dying condition, which was due, in part at least, to the effects of the fungus.

5. *MELAMPSORELLA ELATINA* (Alb. & Schw.) Arth.

In the Rouett national forest this species of rust is common in its aecial form on *Abies lasiocarpa* (Hook.) Nutt., and its effect on the trees is decidedly injurious. In the Manti national forest the effect of the fungus is even more marked on this host.

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THE POWDERY SCAB OF POTATOES
BY STENOSSON SÖDERSTRAND (Wall.) Johns.
H. L. CRESSON

WITH PLATE IV AND ONE TEXT ILLUSTRATION

Some few months ago I received from various localities in Canada samples of potatoes affected with "powdery" or "corky" scab, a disease well-known in Europe but as far as I was able to ascertain hitherto not reported as "established" on any part of the continent of North America. The first samples were sent by some French farmers in the Province of



FIG. 1. Four spore balls of the fungus *Spongospora*. Apparently hollow perforated bodies composed of a large number of spores.

Quebec who had received a copy in French of the 'Potato Canker Danger' poster issued by this Division in August 1912. The French term for potato canker is "gale noire," which is the literal translation of the term "black scab" unfortunately chosen in England to describe potato canker. "Gale noire," however, is a term which describes the external appearance of the "powdery scab" very accurately, as may be judged from an examination of the accompanying plates, so that the action of the French farmers can be easily understood.

The plant pathologist will readily distinguish this form of scab from the Oospora, or common scab, by the characteristic spores of the fungus causing this trouble. Farmers, however, are liable to confuse it with the



PLATE IV—SCAB OF POTATOES

a Oospora scab. *b* Spongospora scab, note close resemblance in this stage. Three tubers badly malformed by powdery scab. Sometimes confluent, sometimes more than half of the tuber is destroyed. *d* This tuber shows very characteristic Spongospora lesions, some still covered by the original thin membrane which on bursting, reveals the olive brown powdery scab. *e* Section through tuber affected by Spongospora scab. *f* Section through tuber affected by Oospora scab.

ordinary scab, especially in the earlier stages. This was the experience in Canada, the farmers claiming to have known the "scab" since childhood—a period which in many cases appeared to date some forty or fifty years back. Since the first account of this disease in Europe by Brunchhorst appeared in 1886 it seems hardly probable that the disease was present so long ago in Canada.

Some of the more important literature on the subject is cited at the end of this note. Nothing new is to be added beyond the establishment of the first record, if I am correct, of its occurrence in North America. The disease seems well established in some counties of the Province of Quebec, while some quite isolated cases in widely separated regions in Canada (Cape Breton, Nova Scotia, New Brunswick, Ontario, Alberta) indicate the introduction of the disease by the use of affected seed potatoes. Recent specimens of potatoes received from Newfoundland also showed the presence of this disease in that country. These facts suggest that powdery scab probably occurs in the United States, also. It should be looked for especially in cases where seed potatoes have been imported from Europe.

The disease should by no means be regarded lightly. Severe attacks occur when potatoes are planted year after year on infected land. Where this is practiced the result will be potatoes hardly superior in quality to those badly affected by canker. This fact is worthy of notice, especially since, as in the case of canker, no preventive measures have proved of much value. It is my intention to establish a field laboratory in Quebec, in order to test probable means for controlling the disease.

Specimens of potatoes affected with powdery scab are at the disposal of any of my American colleagues, who will kindly intimate to me their desire of receiving the same.

DEPARTMENT OF AGRICULTURE

DOMINION OF CANADA

OTTAWA

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A ROT OF GRAPES CAUSED BY CRYPTOSPORELLA VITICOLA

C. T. GREGORY

WITH TWO FIGURES IN THE TEXT

While determining the amount of black rot in clusters of Niagara grapes during the latter part of September, 1911, a large number of berries were observed which were very recently rotted or only slightly spotted with the rot. Since this is not the usual action of the black rot fungus on ripe grapes, the writer was curious to see in what condition the fungus could be to cause such late infections. An examination of numerous cross sections of these mummied berries showed that they were not produced by the black rot fungus but by one having oblong spores borne in flattened pycnidial chambers.

The lesions on the naturally white berry are dark bluish-purple but become more brown as they grow larger. They occur at any place on the berry, but apparently center about the lenticels, spread slowly and finally involve the entire berry. When the spots cover about one-half of the fruit there appear within them small black bodies which gradually become more prominent, until in the mummy they show as relatively large projections thickly scattered over the surface. These are the pycnidia. Under moist conditions the spores ooze abundantly from them.

The differences between these mummies and the black rot mummies are: (1) they do not become so completely shriveled and hard as do the latter; (2) their color is a very dark blue as compared with the dead or brownish-black of the black rot; (3) the pycnidia are much larger and less numerous.

Numerous cultures were made from the mummies and also from beneath lesions of various sizes, thus eliminating the possibility that any fungus obtained could be a saprophyte following the black rot. In these cultures there soon developed an abundant white mycelial growth which eventually produced globose pycnidia of various sizes. There oozed from these pycnidia a yellow wormlike mass of spores. In appearance the cultures are exactly like those obtained from necrotic vines affected with the dead-arm disease. Examination of the spores show them to be of the same size and shape as those occurring in the mummies, i.e., oblong, and measuring $7-12 \times 2-4\mu$.

Stained microtome sections of pycnidia from the cultures and from the berries were prepared. The pycnidia in the berry are relatively small

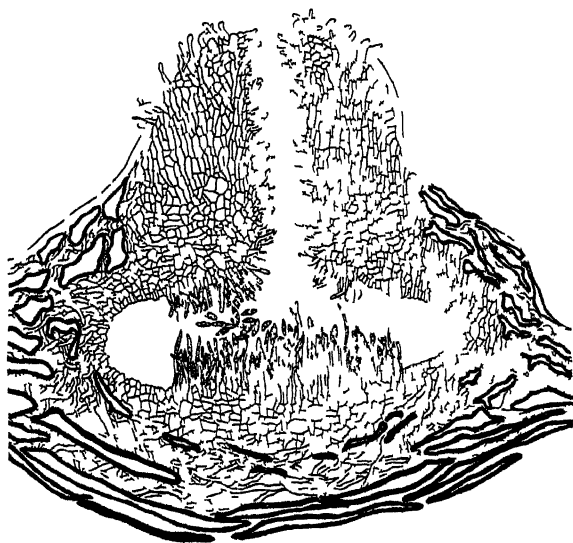


FIG. 1 A pycidium from a mummied grape. Such forms are most abundant in the grape, while in culture the multilocular forms are more abundant.

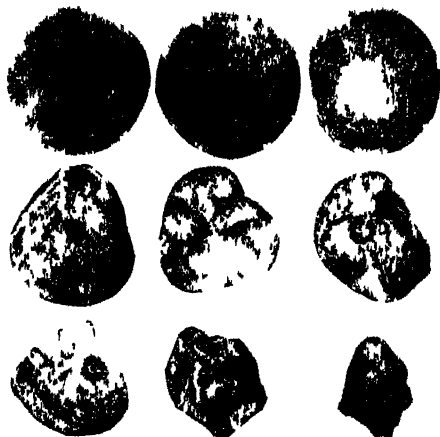


FIG. 2. Stages in the rotting of the grape. The first two stages showing discoloration centering about the lenticels.

and flattened, and the entire cavity is lined with basidal cells bearing the spores. Between these are other sterile threads which extend beyond the spores. The only difference between the pycnidia from the culture and from the berry is that the former are usually considerably larger. The cavity may be unilocular but it is ordinarily composed of several loculi. In the cultures there is often a large stroma containing numerous pycnidia.

When compared with cultures of *Cryptosporella viticola* in its conidial stage, it is seen that the spores are the same and, moreover, there are numerous cases where typical scoliospores were found in the cultures made from the berries. The fact that certain cultures do not produce these scoliospores does not indicate that the fungus is not *Cryptosporella viticola* (Red.) Shear, since numerous cultures of the type *Pusicocum viticolum* Red. were examined and in some cases these organs were not found.

The mummies were left on the ground over winter in the hope that a perfect stage would develop, but in the spring only pycnospores were found. These readily germinated when placed in water and thus, in a way, obviate the necessity for the perfect form.

Inoculations were made with the spores, from pure cultures, on clusters of Niagara and Malaga grapes suspended in a moist chamber. In eighteen days the typical rot appeared and the berries were finally mummified. The same fungus was reisolated from these berries. Spores from pure culture, in sterile water, were sprayed on young grape vines in the greenhouse and kept moist for a few days. In about a month typical necrotic lesions appeared on the stems of certain of the vines. From these stems the fungus was again reisolated. When left in the moist chamber for some time there oozed from the lesions curls of spores which were the same in size and appearance as those obtained from the berries.

During the summer of 1912 numerous inoculations were made on grape shoots which were enclosed in lamp chimneys. About 75 per cent of the inoculations were successful. No attempt was made to reisolate the fungus. All attempts to infect ripe Delaware grapes were unsuccessful; no mature Niagaras were available at the time.

The rot was again found in 1912 at Romulus, N. Y., on the variety Niagara, and the same fungus was isolated.

CONCLUSIONS

The berries are attacked shortly before, and at maturity, by the same fungus that causes the dead-arm disease of the grape vine, producing a rot which in all its stages of development is very similar to black rot.

SEPTORIA PISI IN RELATION TO PEA BLIGHT

I. E. MELHUS

WITH PLATE VI

The investigation of *Septoria pisi* (West.) in its relation to pea blight was started in June, 1911. At this time the Wisconsin Experiment Station was receiving many inquiries as to the cause of certain damages to the pea crop in all sections of the state. Most of the growers sustained a loss of 25 per cent and in some cases whole fields were a total failure. The damage to the crop manifested itself as follows: (1) in the destruction of some or all of the diseased plants early in June, following a spell of wet weather; (2) in injury to the stems of plants less severely attacked so that the pods did not fill or so that the plants wilted down and dried up during the hot weather in the early part of July, before the pods had reached sufficient maturity to be used for canning purposes.

The plants killed early in June did not seem seriously infected, judging from the appearance of the leaves, but the lower third of the stems was blackened and shrunk. In some cases, however, pycnidia of *Septoria* were present on the lower diseased leaves and petioles, but they were not abundant, apparently due to the death of the plants before the fungus had time to fruit. In the majority of cases the stems were more severely attacked at the nodes. The nature of such an infection is clearly shown in plate I, figures 4 and 6. A plant taken from a field so badly blighted that it was not harvested is shown in plate VI, figures 1 and 2. The lower leaves and the basal portion of the stems were in every case thickly sprinkled with mature pycnidia of *Septoria*. The general effect on the plant is evident from the number and size of the pods.

It is well known from the investigations of Hiltner,¹ Krüger,² Jarius³ and Van Hook⁴ that *Ascochyta pisi* may cause severe damage to the pea, much resembling that described above. However, in these cases

¹ Hiltner, L. Über die durch *Ascochyta pisi* hervorgerufene Wurzelkrankheit der Erbsen. Centbl. Bakt., Abt. 2, 1: 581. 1895.

² Krüger, F. Ungewöhnliches Auftreten von *Ascochyta pisi* Lib. an Erbsenpflanzen. Centbl. Bakt., Abt. 2, 1: 620. 1895.

³ Jarius, Max. Untersuchungen über *Ascochyta pisi* bei parasitischer und saprophytischer Ernährung. Bibliotheca Botanica 34: 1-21. 1896.

⁴ Van Hook, J. M. Blighting of field and garden peas. Ohio Agr. Exp. Sta. Bul. 173: 231. 1906.

Ascochyta was not present in any quantity, but another imperfect fungus, *Septoria pisi*, which has not, heretofore, been reported as very destructive, was associated in great abundance. This led me to take up the study of *Septoria* in order to learn whether it might cause such symptoms as were noted in the field, as well as to learn its pathogenicity and distinguishing characters, so that it might not be confused with *Ascochyta pisi*.

Artificial infection experiments. Pea plants of all ages and of several varieties were subjected to infection, at different times, from July, 1911, to October, 1912. A large number were infected with uniform results so it is not necessary to relate the details of the numerous experiments at this time. The plants used were grown in 6-inch pots or in small flats. These were infected by spraying with a suspension of spores, after which the plants were incubated at 22 to 24°C. in a saturated atmosphere for twenty-four hours. Especial effort was made to infect pea seedlings from 2-to 6 inches high, since it is in this stage that the greatest damage is done in the field. Infection developed usually in nine to twelve days, although sometimes it required a longer period. The variation in time was doubtless due to environmental conditions, such as moisture and temperature. The first indication of infection is the development of light-green irregular areas, which may occur anywhere on the leaves, but more often at the margin of the leaflets, due to the collection of droplets of water at this point. Gradually, the color of the infected areas changes from light- to yellowish-green, finally becoming light-brown, due to the death of the infected tissue (pl. VI, fig. 5). There is no tendency to form the dark spots so characteristic of *Septoria* on various other hosts. Instead of this the fungus spreads outward from the initial point of infection until it has included the entire leaflet. It fruits very soon after the infection is well established in the host tissues, as is evident from the photograph reproduced in plate VI, figure 5. The first indication of pycnidia appears about four days after the infection is evident, or from nine to twelve days after the plants are exposed. At this time the surface of the infected area is rough and irregular and on the fifth day the pycnidia have come through the epidermis and are plainly visible. In this stage of their development they are light-yellow in color and filled with spores. As they become older they gradually change from light-yellow to brown and finally become black.

The fungus does not stop after destroying the leaflet; it has only begun its destructive work. It enters the petiole and travels down into the stem. It is here that *Septoria* does its damage, especially if the plant is young when attacked. The infection kills the stem tissues, thus interfering materially with the normal functions of the plant. If the infection is sufficiently vigorous it kills the host in a few days, otherwise the plant

may remain alive for some time, dying gradually. A large proportion of the infected plants go on to maturity and materially reduce the yield, which depends, of course, upon the extent and age of the plants when infected. The pycnidia of *Septoria* do not appear as quickly on the stems as on the leaves and only develop when the host plant begins to mature. At this time it is not unusual to find the fungus fruiting on the lower half of the stems, as is shown in plate VI, figure 1. My infection experiments show plainly that *Septoria pisi* attacks and kills both the leaves and stems of the pea when artificially infected and that the greatest injury results from stem infection. Symptoms like those found in the blighted fields have been produced, which suggests that the damage done in the open may well have been due, in part at least, to the *Septoria*.

Outdoor infection experiments. In order to study the effect of *Septoria* under more normal conditions than was possible in the greenhouse, experiments were conducted in the pathological garden. Plants 6 inches tall were exposed to infection in the manner already described, but without positive results. This was not at all surprising because the weather from July 14, 1911, the time the plants were exposed to infection, until July 27 was very dry and hot, a condition under which *Septoria* does not flourish in the field.

It was thought advisable to approximate field conditions more closely and allow infection to take place by natural agencies. For this purpose three plots, each 6 feet square, were selected and prepared for planting. Two of these plots adjoined and the third was about 5 rods distant. In one of the two adjoining plots, which I shall call A, pea vines were partially buried in a manner comparable to plowing. These pea vines were taken from a market garden in the vicinity of Madison where *Septoria* was very abundant and destructive. Pycnidia were very numerous on these vines and examination showed that many were still filled with viable spores. Alaska peas were planted in the three plots on August 8. The rain of the following night made conditions immediately favorable for the peas to germinate, and in six days they were up. On August 21 infections began to appear on the lower leaves, which became yellowish-green in irregular areas and finally light-brown, due to the death of the tissues. This infection was identical with the one resulting from the exposure of pea plants to *Septoria* in the greenhouse. The infection spread throughout the leaf tissue in the way already described, and when the leaflets had been destroyed the fungus attacked the petioles and traveled down into the stem.

Careful count of the plants in plot A on August 24 showed that 90 per cent were infected. Early and abundant infection was undoubtedly favored by the damp moist weather that followed several days after the peas

came up. It was especially interesting to note that on the first three rows of plot B, adjoining plot A, the amount of infection was about the same, but in the remaining rows of plot B there was less, possibly only 75 per cent. This suggested that the source of infection was the dead pea vines in plot A. It is also probable that the wind was the chief agency in distributing the spores. Careful examination of control plot C, 5 rods to the south, beyond several rows of corn and tobacco, showed no evidence of *Septoria* previous to August 24. This fact further shows that the source of the spores was the infected pea vines.

Observations made on August 29 showed little or no leaf infection on any of the plots. The infected leaflets had been killed and dried up and the only evidence of infection at this time was on the stems, especially near the surface of the soil. These were discolored and shrunk at the nodes where the diseased leaves had been attached. Some of the plants were already dead, while the rest were less vigorous than the healthy ones in the control plot. New infection of the younger leaves had been checked by the hot dry weather that intervened between August 18 and 29. *Septoria pycnidia* containing mature spores were found September 5 on infected petioles. This further established the fact that *Septoria* was the fungus causing the damage and that the infection might take place through natural agencies.

No further results worthy of mention developed until September 18, when an outbreak of *Ascochyta* occurred. The vines at this time were nearly a foot tall and lay semi-prostrate on the ground. The source of this infection was doubtless a small plot of peas less than two rods distant that were infected with *Ascochyta* earlier in the season, and which had only recently begun to fruit, so that they were well covered with mature pycnidia. *Ascochyta* developed on all three of the plots, although not so extensively on the check plot. This was doubtless due to its greater distance from the vines producing the *Ascochyta* spores. As I shall explain later, the early symptoms of *Ascochyta* are distinctly different from those of *Septoria* so this outbreak led to no confusion. It was not until September 23 that I was able to find any new *Septoria* infections and these were not numerous. This decrease in the amount of *Septoria* I attributed to the lack of spores, as the supply contained in the pea straw had functioned earlier and the fungus had not had sufficient time to fruit extensively.

In order to gain additional evidence, the experiment was repeated. *Septoria*-infected pea vines that had been collected on the same date as those used earlier and kept in the laboratory were partially buried, as in the previous experiment. Peas were planted August 22, two weeks later than in the preceding experiment. *Septoria* came on in much the

same way as already noted, so it is needless to describe the results further. It is clearly shown that infection can be obtained on pea plants in the open and that symptoms like those found under field conditions develop. These facts, coupled with many observations, make it quite conclusive that Septoria was an important factor in the damage done by pea blight in Wisconsin during the season of 1911.

Symptoms of Septoria and Ascochyta. The symptoms of Septoria on the pea have never been clearly defined and it is reported by Halsted,⁵ and Stevens and Hall⁶ that Septoria and Ascochyta can not be distinguished from one another on the host without the aid of the microscope. This is very true in certain late stages of the two diseases, but the early symptoms are quite unlike and are readily distinguishable. For instance, it is known from the results of Kruger,⁷ Van Hook⁸ and my own studies that Ascochyta produces spots with ashen-white centers surrounded by dark borders. Septoria, on the other hand, produces no distinct spot and the first indication of infection is the appearance of yellowish-green irregular areas, which later become light-brown, due to the death of the tissues. Primary infection with Septoria seldom, if ever, occurs directly on the stem, while this is a very common occurrence with Ascochyta. Septoria reaches the stem at the nodes by attacking the petiole and stipules, as is shown in plate VI, figures 4 and 6. If the infection occurs early the plant may become girdled (pl. VI, fig. 6). Ascochyta causes pronounced lesions anywhere on the stem, which may, and usually do, coalesce and girdle the plant if the infection is severe. Late stages of stem infection, both before and after the fungi have fruited, are not readily distinguishable.

Mycosphaerella pinodes (B. & Blox.) Johans. On October 24 some of the dead vines from plot A were brought into the laboratory and examined for Septoria and Ascochyta. Both fungi were present, as well as a small ascomycete. On the same day another collection was made from the plot that was so generally infected with Ascochyta earlier, and perithecia were found to be very abundant. Most of them were immature, but a few were found that contained mature spores. The asci were short and eight-spored. The two-celled spores were constricted in the middle and somewhat pointed at each end, with prominent oil droplets in each cell. The average of sixteen measurements showed them to be 16 x 6.5 microns.

This is doubtless the species listed by Cook⁹ as *Sphaeria pinodes* (B.

⁵ Halsted, B. D. Some fungous diseases of the pea. New Jersey Agr. Exp. Sta. Rept 1893, p. 357.

⁶ Stevens and Hall. Diseases of economic plants, pp 255-259. 1910.

⁷ Loc. cit.

⁸ Loc. cit.

⁹ Cook, M. C. Handbook of British fungi 2 909. 1863.

& Blox.), although there is a little difference in the spore measurements. Later, the subgenus *Sphaerella* of Fries was raised to generic rank by Cesti and de Notaris, and Saccardo¹⁰ subsequently lists two species of *Sphaerella*, viz., *S. morici* (Cke) Sacc., occurring on the dead leaves, and *S. pinodes* (B & Blox.) Niessl., occurring on the stems. The descriptions of these two species are otherwise quite alike and it is not at all improbable that they represent the same fungus. Grove¹¹ has recently shown that *Sphaerella* was established in 1824 by Sommerfelt for a group of algae and is not correctly used as a fungus genus, and that the name *Mycosphaerella*, which was established by Johansson in 1884, should be used as the name of the fungal genus. It is suggested by Saccardo that *Mycosphaerella pinodes* may be the perfect stage of *Septoria pisi*. Potebnia,¹² who has collected and studied *Septoria pisi* in Russia, is, likewise, of the same opinion. However, the following experiment tends to show that such is not the case. Single spores of this ascomycete grown in pure culture on potato agar produce *Ascochyta* pycnidia. The spores were isolated by the dilution method and individual ones were located and transferred to other plates. Six spores were thus obtained, all of which produced *Ascochyta* in pure culture, except in one case where there was bacterial contamination. Spores taken from these pure cultures of *Ascochyta* and used to infect young pea plants produced *Ascochyta* lesions in quantity, but no *Mycosphaerella* developed on the plants, even after they were dead. Thus, the evidence was not conclusive that *Mycosphaerella* is the perfect stage of *Ascochyta*. It should be noted, however, that the failure to obtain *Mycosphaerella* on *Ascochyta*-infected plants in the greenhouse should not be construed as demonstrating positively that no relation exists between the two fungi. The abnormal environmental conditions in the greenhouse may well prevent the formation of the perfect stage.

It was next thought advisable to isolate immature perithecia and grow them in pure culture. This was done, and *Ascochyta* again developed. This test was also very suggestive as to the relation of the two fungi concerned. In view of the fact that *Mycosphaerella* appears to be related to *Ascochyta* rather than *Septoria*, further study of it was discontinued by the writer and taken up by R. E. Vaughan, who is making an extensive study in this laboratory of pea blight caused by *Ascochyta*.

It is not known how *Septoria* passes the winter, although my results and observations tend to show that it must have a perfect stage which functions in this capacity. That the pycnospores can not perpetuate the

¹⁰ Saccardo, P. A. *Sylloge Fungorum* 13: 877.

¹¹ Grove, W. B. *Sphaerella* v. *Mycosphaerella*. *Journ. Bot.* 50: 89-92. 1912.

¹² Potebnia, A. *Beitrag zur Micromyceten Flora Mittel-Russland*. *Ann. Myc.* 8: 70. 1910.

disease from year to year is quite conclusive. Infected pea vines, which contained large quantities of viable spores at the time of collection in June and July, were stored in the laboratory and from time to time the germinating capacity of the spores was tested. Their viability decreased until in February none germinated. Again, it might be argued that *Septoria* infects the seed and perpetuates itself from one year to another in much the same way as *Ascochyta* is known to do, but this is not in accordance with my observations and experiments. The pods become abundantly infected with *Septoria* (plate VI, fig. 2), but the mycelium does not penetrate through the pod into the seeds. Peas have been soaked for twenty-four hours and then exposed to *Septoria* infection by spraying with spores and subjecting them to favorable conditions for the growth of the fungus. In no case has infection of the seed resulted. Pea vines known to have been infected in the late summer and fall with *Septoria* have also been examined for *Septoria* spores in the spring, but in every case the pycnidia have been found empty. Viable spores have been placed in water on slides and subjected to temperatures varying from 0 to -10°C . for twenty-four hours and then returned to the laboratory and subjected to favorable conditions. In every case the spores failed to germinate. Similar spores dried on slides and subjected to low temperatures have also refused to germinate when favorable conditions were restored.

It is not improbable that *Septoria pisi* has a perfect stage which is instrumental in starting infection in the spring. It was observed that the fields became very generally attacked early in June when the peas were from 2 to 6 inches high, depending upon the time of planting and weather conditions. If the fungus propagated itself through the seed one ought to find certain areas in the field more generally infected than others, during the early development of the disease, but such is not the case. On the other hand, I have examined whole fields and found the infection uniform, suggesting that spores were either produced locally, or at some distance and distributed by the wind. Several ascomycetes occur on the dead straw but their relation to *Septoria* is not known at the present writing.

Cultural studies. *Septoria* has been grown in pure culture by Potebnia,¹³ who found that it produced conidia and dense balls, but no further details regarding its cultural characteristics are given. I have obtained the fungus from young infections in the leaves and from single spores isolated by the plate dilution method, but have not been successful so far in getting it to produce normal pycnidia, although it has been grown on a wide range of media. It grows slowly, and especially so, immediately after it

¹³ Loc. cit.

has been obtained from the host tissues, but after it has been transferred a few times it develops more rapidly. In this respect it behaves in the same way as *Septoria pyricola* studied by Duggar. The submerged mycelium is dark colored and tends to form a thick crust which is covered by a thin white layer of mycelium. In the aerial mycelium are found stromatic masses which also become dark colored and have the general appearance of pycnidia, but so far none of them have been found to contain spores. These empty pycnidia tend to form more abundantly when the culture begins to dry out. The two-celled conidia are formed on side branches of the hyphae and have the same dimensions as the pycnospores. It should be noted, however, that conidia formation has been secured only in cultures several months old. Whether there is some correlation between moisture content and conidial formation is not known, but my results are suggestive. It has already been pointed out by Stevens and Hall¹⁴ that colonies of *Septoria lycopersici*, grown under crowded conditions, produce naked spores, while, otherwise, pycnidia are formed in great abundance.

DEPARTMENT OF PLANT PATHOLOGY
UNIVERSITY OF WISCONSIN

EXPLANATION OF PLATE VI

FIGS. 1, 2, 3, 4. Plants infected with *Septoria pisi* taken from badly diseased fields.

FIGS. 1, 2. A plant killed by *Septoria*; 1, the fungus fruiting on the lower portion of the stem; 2, the upper portion of plant shown in Figure 1—note the absence of *Septoria* and the small pod.

FIG. 3. *Septoria* infection and pycnidia on pod and petiole.

FIG. 4. A stem infected at the node with *Septoria*; primarily caused by leaf infection. Magnified four diameters.

FIGS. 5, 6. Symptoms of *Septoria* produced by exposing young pea plants to infection in the greenhouse; 5, early stages of leaf infection; 6, late stages of leaf and stem infection.

¹⁴ Stevens, F. L. and Hall, J. G. Variation of fungi due to environment. North Carolina Agr. Exp. Sta. Rept. 32: 47. 1909.



PLATE VI PLA BLIGHT

SOME SUCCESSFUL INOCULATIONS WITH THE PEACH CROWN GALL ORGANISM AND CERTAIN OBSERVATIONS UPON RETARDED GALL FORMATION

CLAYTON O. SMITH

The wide range of hosts susceptible to infection with *Bacterium tumefaciens* has been well established through the work of Dr. Erwin F. Smith and his associates. Certain hosts that have never before been reported as susceptible have been successfully infected at our laboratory by artificial inoculations. The following is a list of plants upon which galls have thus been artificially produced:

Anacardiaceae: *Schinus molle*, pepper tree.

Ebenaceae: *Diospyros kaki*, Japanese persimmon.

Juglandaceae: *Juglans californica*, Southern California black walnut; *J. californica* var. *hindsii*, Northern California black walnut; *J. cinerea*, Butternut; *J. nigra*, Eastern black walnut; *J. regia*, English walnut; *J. sieboldiana*, Japanese walnut; *Hicoria pecan*, pecan.

Myrtaceae: *Eucalyptus tereticornis*, Forest red gum.

Rosaceae: *Cydonia* sp., Angiers quince; *Prunus amygdalus*, hard-shell and bitter almond; *P. armeniaca*, apricot; *P. avium*, mazzard cherry; *P. allegheniensis*, Allegheny plum; *P. davidiana*, ornamental almond; *P. domestica*, prunes, vars. Clyman, Yellow Egg, Sugar, Tragedy, French, Hungarian; *P. cerasifera*, vars. Myrobalan, Marianna; *P. mahaleb*, Mahaleb cherry; *P. orthosepala*, Texas plum; *P. persica*, peach, varieties Lovell, Muir, Salway; *P. platycarpa*, Peen-to or Saucer peach; *P. simonii*, Simon plum; *P. triflora*, plum, vars. Burbank, First, Kelsey, Satsuma, Wickson; *Pyrus betulifolia*, Chinese pear; *Py. communis*, French pear stock; *Py. pashia*, Chinese pear; *Laurocerasus lyonii* (*Prunus integrifolia*), Catalina cherry.

Rutaceae: *Citrus aurantium*, Valencia orange; *C. vulgaris*, sour orange; *C. limonum*, Eureka lemon; *C. limetta*, sweet lime.

Sterculiaceae: *Sterculia diversifolia*, Victoria bottle tree; *St. acerifolia*, flame tree.

Urticaceae: *Ficus carica*, fig.

Markedly retarded gall formation has been observed in two instances, that of Angiers quince and fig. In both cases the inoculations were made after rapid growth had ceased.

Angiers quince. A vigorously growing sprout of the current year's growth was puncture-inoculated on June 3, 1911. Up to January 23, 1912,

no galls had been found and no further observations were recorded until July 16, 1912, when small knot-like galls from one-sixteenth to one-eighth of an inch in height were found to be forming in the healed-up tissue of the old scars. Further inspection of these galls on October 15, 1912, showed that they had increased slightly in size and were becoming rougher or more warty. This tree has also what is believed to be the aerial quince knot, so common on quince trees in California, but these knots seem to differ from the artificial galls, both in manner of growth and shape. No natural knots have been found on the inoculated branch, nor do they appear until the wood becomes several years old.

It is interesting to note that similar retarded gall formations were observed by Dr. Erwin F. Smith and his associates in their inoculation of quince seedlings with cultures of the hairy root organism.

Fig (Ficus carica). A fig tree was inoculated on two branches August 24, 1910. Observations were taken at various times, as the tree was easily accessible, but no galls developed until early in 1912. At first there were only slight prominences that could scarcely be taken for galls. The particular branches that were inoculated had not been growing well and to stimulate new growth they were cut off just beyond the points of inoculation. On February 22, 1912, one branch showed a large gall and several smaller ones. The other inoculated branch showed, on June 15, 1912, one small gall. Growth in the part inoculated seems to be a necessary condition for the formation of galls, but the organism is able to live in the tissue for a considerable period of time (in this case one and one-half years) without apparent gall formation.

SOUTHERN CALIFORNIA PLANT DISEASE LABORATORY

UNIVERSITY OF CALIFORNIA

WHITTIER, CALIFORNIA

ENDOTHIA RADICALIS (SCHW.)

C L. S H E A R

In a previous note¹ we expressed the opinion that *Endothia radicalis* (Schw.) was based on the long ascospore form illustrated by Ellis and Everhart² as *E. gyrosa* (Schw.). This according to our present information appears to be an error, unless Schweinitz mixed two collections under this name. Only one collection, however, is mentioned in his published works. The specimen in Schweinitz's Herbarium at Philadelphia appears to show only pycnidia and we judge from Farlow's published statement that the one in his collection is in the same condition. There is in the Kew Herbarium an autograph specimen from Schweinitz, apparently on oak roots, which shows perithecia and ascospores. This is evidently the specimen which Schweinitz sent Hooker, and which was described and illustrated by Curry.³ A slide from this specimen show ascospores 6.3 to 8.6×2.8 to 3.6μ , agreeing very closely in appearance with the two upper spores in Curry's figure. The two lower spores with two to three septa shown in his figure are unlike anything we have found on our slide from this specimen and they may belong to something else. The specimen of Schweinitz's species which should be regarded as the true type, however, is that sent by Schweinitz with his diagnosis to Fries and used by him in his description in *Elenchus Fungorum*. This specimen is preserved in Fries' Herbarium, is apparently on oak roots, and shows perithecia; but no measurements or description of the spores from this specimen have ever been published. The Kew specimen appears practically identical with *E. virginiana* And.

In the article referred to we also said that *Diaporthe parasitica* was probably introduced into this country from Europe. This statement was based chiefly upon the results of inoculation experiments made with material kindly given us by Dr. Pantanelli, of Rome, as of Italian origin, and which produced typical chestnut-blight cankers in the inoculation experiments referred to. We have since learned from Dr. Pantanelli that the material which he gave us was probably *D. parasitica* which he had in the laboratory at the time and which was given us by mistake for the Italian fungus. Other inoculations with the native Italian *Endothia* have not yet produced the disease.

¹ Phytopathology, 2: 211. Oct. 1912.

² North American Pyrenomycetes, pl. 30. Figs. 6-8. 1892.

³ Transactions Linnaean Society, 22: 272. Pl. 47. Fig. 89. 1858.

PHYTOPATHOLOGICAL NOTES

Notes on Cronartium comptoniae. While making observations upon *Cronartium comptoniae* Arthur within a rather limited area counts were made of recently killed trees of *Pinus rigida* which bore signs of the attacks of this fungus. Within this area 147 living trees were found bearing the fruiting bodies of *Cronartium comptoniae* and 8 trees were found which had evidently died within two or three months and which evidently had been attacked by the fungus. That is, there was an evident annual mortality of approximately 5 per cent from the attacks of the fungus. Fires have had no effect within this area, as young pines were planted there several years ago and fire has been kept out since that time. The observations were made shortly after the uredo stage began to fruit and thus an excellent chance was given to determine the approximate distribution of the aecidiospores. It was found that the uredospores were distributed (in this case) in a definite direction from the diseased pines. That is, the distributing wind seems to have been fairly constant and the uredo stage, in each case, covered a fan-shaped area which had the infecting pine at the apex. The uredo stage at that time was practically all within ten yards of the point of infection. Undoubtedly, an extra hard wind or a small whirlwind might have taken the aecidiospores much further. The evidence shows that the great mass of aecidiospores is ordinarily blown but a short distance.

During the summer of 1912 the writer received young trees of *Pinus sylvestris* and *P. ponderosa* diseased with a *Peridermium* on the stems. Inoculations were made in the open upon *Comptonia asplenifolia* where *Cronartium comptoniae* has never been seen for over ten years. These inoculations were successful upon the inoculated leaves, which were enclosed in waxed paper bags, and in no case was the fungus found except on the inoculated plants. The uredo stage developed about two weeks after inoculation and several weeks later the teleuto stage also developed. So far as the writer knows this is the first time the transfer has been made from *Pinus ponderosa* to *Comptonia*.

PERLEY SPAULDING.

Winter injury to the white elm. During August, 1912, the attention of the writer was called to a general diseased condition of trees of *Ulmus americana* in Rockford, Illinois. An inspection of certain areas of the

city showed a very unthrifty condition of many of the trees, associated with a killing back of the top and, in many cases, a sloughing off of the outer bark nearly to the cambium. Limbs were frequently killed back for a distance of 10 to 15 feet, but bore no signs of parasitic fungi, although an occasional saprophyte was found.

The sloughing of the bark was the most interesting feature. This was limited, in some cases, to small areas at the base of the trunk, but in many other instances, the loosened layers, which could only be located by tapping the bole, could be stripped off the trunk, either partly or completely, to a height of 10 to 15 feet, or more. The cambium, except in an occasional very limited area, was living. The cleavage plane just outside the cambium usually appeared peculiarly sculptured, apparently due to growth phenomena after the injury had occurred. Since the loosened bark has persisted on the trunk for a season or more it bore considerable evidence of the activity of small bark borers. Larvae of the elm borer however, were scarce, and little indication of their presence was met with. Although a member of the Agaricaceae (*Marasmius* sp.) was found abundantly fruiting on the outer bark, at or near the base of many trees, an investigation did not reveal a causal relation of this organism to the trouble.

In addition to these distinct phenomena of limb and bark injury, other elm trees only showed decreased vigor, coupled with a yellowing of the foliage and early leaf fall.

With proper attention to culture methods, and a pruning out of dead limbs, the trees will probably gradually recover, in most instances, unless nature interferes again too unfavorably.

During pruning operations it is very essential that all freshly-cut surfaces be treated with an antiseptic coating in order to prevent the entrance of saprophytic decay organisms. Asphaltum has been highly recommended as a wound dressing for trees, but in lieu of this a thick lead paint will serve the purpose well.

C. J. HUMPHREY.

Personals. Mr. C. R. Orton, lately assistant botanist in the Indiana Experiment Station, has been appointed botanist of the Pennsylvania Experiment Station. Miss Adeline Ames has accepted a position as assistant forest pathologist in the Bureau of Plant Industry. The address of Dr. Ernest Shaw Reynolds, stated erroneously in the last number of PHYTOPATHOLOGY, is the North Dakota Agricultural College, Agricultural College, N. D. Dr. Ormond R. Butler, formerly instructor in horticulture in the University of Wisconsin has been appointed botanist in the New Hampshire Agricultural College and Experiment Station. H. E. Truax has been appointed assistant plant pathologist in the Arkansas University

and Experiment Station. R. A. Studhalter, recently assistant in botany in the Kansas Agricultural College, has been appointed agent in forest pathology in the Bureau of Plant Industry. His address is Zoological Building, University of Pennsylvania, Philadelphia, Pa. Orlo A. Pratt has been appointed assistant in plant pathology in the Idaho University and Experiment Station.

CLEVELAND MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The fourth annual meeting of the Society was held in Cleveland, Ohio, December 31, 1912, to January 3, 1913 in conjunction with the American Association for the Advancement of Science.

Over fifty members were in attendance and a program of fifty papers was presented. The total membership at present is 240. Seven new members were elected at this meeting. Joint sessions were held with Section G of the American Association for the Advancement of Science and also with the Botanical Society of America.

The following officers were elected for 1913.

President—F. C. Stewart, New York Agricultural Experiment Station, Geneva, N. Y.

Vice-President—Haven Metcalf, U. S. Department of Agriculture, Washington, D. C.

Secretary-Treasurer—C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

Councillor—W. J. Morse, Maine Agricultural Experiment Station, Orono, Maine.

The Society decided to hold its next annual meeting at Atlanta, Georgia, in conjunction with the American Association for the Advancement of Science.

The present mode of nomination of officers was adopted for the coming year. It was also decided that subscriptions from institutions or libraries cannot be substituted for membership fees of individuals. The Secretary was instructed to drop from the list of members those more than one year in arrears.

At the request of the Botanical Society of America a committee consisting of the newly elected President and Secretary was appointed to consider questions of closer affiliation with the two Societies. Upon motion the President designated the Secretary of the Society to act as its representative to meet with the Secretary of the American Society of Naturalists and other related Societies to consider closer affiliations, especially as to places of meeting and arrangement of programs.

F. C. Stewart was added to the Committee on Common Names of Plant Diseases and made Chairman of the same, the other members being F. L. Stevens, H. von Schrenk, E. M. Freeman, and G. P. Clinton.

The Secretary was instructed to publish the constitution of the Society and a list of the present members and also present and past officers of the Society.

The following resolutions were adopted by the Society:

Resolved, That the American Phytopathological Society, recognizing the fact that plant diseases do not recognize national limits or geographical boundaries and the evident limitations imposed upon investigations when restricted by national boundaries, respectfully recommend that administrators of research institutions, whether state or national, as well as individual investigators, recognize the importance of establishing closer international relations and take such steps as may be practicable from time to time to secure this end, including not only more frequent visits of American investigators to foreign countries for field observations as well as research, but also the securing, either by permanent or temporary engagement of the best of foreign experts in plant pathology.

Resolved, that the Society express its sincere thanks and appreciation to all concerned for the courtesies and accommodations extended to it at the Cleveland meeting.

A Committee on Resolutions regarding the death of Prof. M. B. Thomas, consisting of Donald Reddick, L. R. Jones and W. A. Orton, was appointed. The following resolution was prepared by the committee:

MEMORIAL RESOLUTION OF JANUARY 3, 1913

Professor Mason Blanchard Thomas, Rose Professor of Biology in Wabash College, died March 6, 1912, in the forty-sixth year of his age.

At its first meeting after his death, this Society desires to inscribe upon its records an acknowledgment of the great loss this Society has sustained by the death of Professor Thomas, a scholar, a man of inspiring personality, an enthusiastic teacher of botany and an energetic supporter of our Society.

Professor Thomas was graduated from Cornell University in 1890 with the degree of Bachelor of Science and was the same year appointed Fellow in Botany in that institution. The following year he was appointed Professor of Biology at Wabash College, a position which he held until his death. Professor Thomas was deeply interested in his profession and took an active interest in the scientific meetings. He was a fellow of the American Association for the Advancement of Science, at one time a member of the council, a member of this Society, an active member and one time president of the Indiana Academy of Science, Vice-President of the Indiana State Forestry Association and a member of the honorary Societies of Sigma Xi and Phi Beta Kappa. He was honored by Wabash College June, 1907, with the degree of Doctor of Philosophy.

The published works of Professor Thomas are not numerous but his keenness for investigation is well known to more than two score young men who have entered the profession under his guidance and tutelage, while his optimism and enthusiasm for things worth while are known to many scores of students.

This expression of esteem for a colleague cut off in the midst of his achievements and his plans is inscribed with sorrow upon the minutes of this Society.

DONALD REDDICK,
L. R. JONES,
W. A. ORTON,

Committee.

Resolved, That the matter of the form of papers to be presented at the next meeting, whether in full or by abstract and discussion, be referred to the Council with power to act and the privilege of taking a referendum by mail, if deemed advisable.

In accordance with this resolution, the Council decided that all members offering papers for the program should present carefully prepared abstracts of about 200 words which should be submitted in sufficient time to permit of their publication before the meeting so that they may be distributed at the opening session. No descriptions or mention by name of new species should be included in these abstracts.

The Business Manager of PHYTOPATHOLOGY presented his report and accounts. The accounts were audited by a committee consisting of W. A. Orton and F. C. Stewart, and approved. The account showed a small balance on hand after all debts connected with the publication of the Journal were paid.

The following editors were elected: L. R. Jones, C. L. Shear, and R. A. Harper, in place of H. H. Whetzel, resigned. The associate editors were all reelected, with the exception of R. E. Smith, who resigned. C. J. Humphrey was elected to fill the vacancy. The Secretary was instructed to divide the associate editors into four

groups of three each: the first group to hold office four years the second group three years, the third group two years, and the fourth group one. This arrangement to be determined by lot.

A motion was adopted making available for the use of the Business Manager in connection with PHYTOPATHOLOGY during the coming year \$200, or such portion thereof as may be necessary, from the funds of the Society.

The Treasurer presented the following report, which was examined and approved by the Auditing Committee:

RECEIPTS

Jan. 1	Cash balance from 1911	\$218 44
Dec. 30	232 membership dues	696 00
Nov. 1	Interest on bank deposit, 1912	8 33
Total		\$922.77

DISBURSEMENTS

Dec. 30	232 membership subscription at \$2	\$464.00
	Stamps, stationery, typewriting, and stenographic work	17 23
	Printing circulars, etc	6 25
	Traveling expenses, Secretary, Cleveland	27 00
Total		\$514 00
	Balance on hand in bank	408 29

The phytopathological exhibit was a very interesting and attractive feature of the meeting.

A symposium on International Phytopathological Problems was held on Thursday and attended by members of Section G of the A. A. A. S., and also the Botanical Society of America.

The following papers were presented at this symposium. Most of these papers will be published in PHYTOPATHOLOGY this year.

The importance of closer international relations in phytopathology. L. R. JONES
Some personal observations on phytopathological problems in Europe and America.
 C. L. SHEAR

Theory and practice of legislation against plant diseases. H. T. GÜSSOW
International phytopathological problems connected with quarantine legislation. W. A. ORTON

Abstracts of the other papers presented, so far as they have been received, follow.

Effect of the steam-formalin treatment on certain soil organisms. J. R. WINSTON
 No abstract.

*A rot of grapes caused by *Cryptosporella viticola*.* C. F. GREGORY
 Published in full in this issue.

*Notes on the genus *Endothia*.* H. W. ANDERSON

A brief summary of the literature dealing with this genus is given, together with a discussion of the species definitely established and the forms recently investigated. The reasons for including the chestnut blight fungus in this genus, and a discussion of *Endothia parryi* (Farl.) follow. The production of pigment by the various species in culture, and its significance, are considered and the formation of the pycnidia and conidia in *E. parasitica* and *E. virginiana* is outlined.

Wind dissemination of the chestnut blight organism. PAUL J. ANDERSON

The ascospore stage of this fungus was found maturing in abundance during every month of the summer. The ascospores are ejected into the air from the ostioles during rain and as long afterward as the bark remains wet. A pustule may eject spores continuously for three weeks if kept wet. The distance to which the spores are shot and the rate of ejection were studied. Tests were made of the spore content of the air by the use of an aspirator and by exposure of sterile plates. By the latter method spores were caught at a distance of 51 feet. The average of a number of aspirator tests gave 4.3 spores per liter of air. Successful inoculations were made by cutting wounds and permitting spores to shoot into them from bark held at various distances. The writer believes that the wind is the most important agent in the spread of the disease.

Some notes on the dissemination of Diaporthe parasitica. F. D. HEALD

No abstract.

Fusarium batatatis Woll. MS., not *Nectria ipomaeae* Hals., the cause of the sweet potato stem rot. L. L. HARTER and ETHEL C. FIELD

For many years *Nectria ipomaeae* Hals. has been regarded as the cause of the sweet potato stem rot. Numerous inoculations, both in the greenhouse and in the field, with conidia and ascospores of *Nectria ipomaeae*, however, have failed to produce the disease. In the greenhouse, where temperatures and relative humidity were high, some of the plants would show considerable injury and enlargement of the wound about the point of inoculation, and perithecia were sometimes formed in the injured areas. The organism, however, never entered the bundles of the stem, and several attempts to isolate it from the living tissue of the plant have always been unsuccessful. When field inoculations were made, the wounds where the spores were inserted healed normally and no injury to the plant resulted.

Another organism, soon to be described by Dr. H. W. Wollenweber as *Fusarium batatatis* has frequently been isolated from the fibro-vascular bundles of the roots, petioles and stem. This has been found to be the real cause of stem rot. A large number of inoculations have been made in the greenhouse and in the field and a large percentage of the plants showed the characteristic symptoms of the disease. The organism has been recovered from the fibro-vascular bundles of the roots, stems and leaves of many inoculated plants, in many cases from the stem 2 to 3 feet from the point of inoculation. A detailed study of the disease is soon to be published.

Studies on the water core of apple. P. J. O'GARÁ

Water core is a trouble which is found wherever apples are grown. It has been reported from all parts of the United States, as well as from Europe, Asia and Africa. It is found more particularly in districts where very great ranges of temperature and relative humidity are experienced. It has been found that the addition of water to orchards, either naturally or artificially, when followed by extremely high maximum temperatures with low humidity during hours of sunshine, and low temperatures with high humidity during the night, will induce water core. Young trees bearing their first crops are more susceptible than older, less vigorous apple trees. Water-cored fruits are found mostly on the terminals and on the south and southwest sides of trees, because such fruits are subject to greater extremes of temperature. The side of a fruit presented to the direct rays of the sun will show more water core than the opposite side. Heavily pruned trees, or trees defoliated shortly before the ripening period begins are very liable to water core if climatic conditions are favorable to the disease.

Moderately water-cored fruits if placed in storage at an even temperature will recover, the water-soaked spots entirely disappearing. Fruits in which the seed cavities have become filled with liquid will not recover. It has been demonstrated beyond doubt by inoculation experiments that water core is not due to the attack of any parasite.

The apothecial stage of Sclerotinia fructigena (Pers.) Schroet. in Ontario in 1912.

J. E. HOWITT

No abstract.

Leaf roll, curly leaf and other new potato diseases. W. A. ORTON

In treating of the diagnosis of diseases hitherto confused, differentiating characters were pointed out for the following troubles:

1. Fusarium wilt, an American disease not yet proved to occur in Europe. Characterized by wilting and early death of the plant, and browning of the vascular tissues of stem, stolon and tuber, which are infected by *Fusarium oxysporum* (Schlecht.) Sm. and Sw.

2. Verticillium wilt, a disease found in America and Europe. Resembles the foregoing, but is associated with the fungus *Verticillium albo-atrum*. Wilting is usually more rapid, vascular browning darker, and dead stalks quickly covered with grey layer of spores.

3. Leaf roll (Blattrollkrankheit), a trouble of unknown nature, probably non-parasitic, characterized by upward rolling of the leaves, a decreased yield of tubers and by hereditary transmission of the diseased conditions. The extensive occurrence of this disease in Colorado and western Nebraska was reported, and it was held responsible for the greater part of the heavy crop losses there in 1911 and 1912.

4. Curly leaf (Kräuselkrankheit), an inheritable, physiological derangement of the potato plant, resulting in dwarfed growth, decreased yield and, particularly, in a shortening of all vascular parts, the stem, branches, petioles and midribs. The leaves are crinkled and curled. Common in Europe and the eastern United States.

5. Rosette, aerial tubers and other troubles distinct from the foregoing and associated with Rhizoctonia lesions on stem, roots and stolons.

The following new potato diseases were described for the first time:

6. Mosaic, apparently similar in nature to the mosaic of tobacco, tomato, etc.

7. Streak. Elongated or angular spots appear on leaves, following the veins. The leaves wither and hang dry on the plant, which soon dies. Cause unknown.

Potato tuber rots associated with Fusarium were also differentiated. The full text will shortly appear as a bulletin of the Bureau of Plant Industry.

Notes on some western Uredineae which attack forest trees. II. G. G. HEDGCOCK

Read by title. Published in full in this issue.

Notes on winter-killing and smelter injury in the forests of Montana. II. G. G. HEDGCOCK

Read by title.

Black pit of lemon. CLAYTON O. SMITH

A bacterial disease of lemons, causing a brownish colored depressed pit on tree-ripe fruit in the orchard, is described. A pathogenic organism, *Bacterium citriputeale* nov. sp., has been isolated and its cultural characteristic studied. Successful artificial puncture inoculations have been made on lemons, limes, oranges and grape fruit.

The American botrytis blight of peonies. H. II. WHETZEL and J. ROSENBAUM

The peony is generally held to be a perennial especially free from diseases. It is, however, subject to several, the most destructive of which appears to be the one here under consideration.

Halsted first applied the name "mould of peonies" to this disease, but in order to specify its causal character and at the same time distinguish it from a similar disease in Europe the name "American Botrytis blight" is proposed.

Halsted who was the first to record the disease, regards it as epidemic in eastern United States in 1897. It is now more or less destructive throughout this section every rainy spring.

The most striking symptoms are the rotting of the stems at the base soon after they are up in the spring, followed later by the blasting and rotting of the unopened buds and the blighting of the leaves.

The disease is caused by a Botrytis. The pathogenicity of the fungus has been fully established by two series of successful inoculation experiments and subsequent reisolations. The identity of the pathogen has not yet been satisfactorily determined but the evidence indicates that it is not identical with *Botrytis paeoniae* Oud., reported by J. Ritzema Bos as a destructive disease of peonies in Holland and Germany, and noted by Massoe as destructive to the same host in England and Ireland. Halsted held it to be but a virulent form of *Botrytis vulgaris*.

The parasite passes the winter in sclerotial form in the old stems or stubble. From these conidiophores bearing conidia for primary infections arise in the spring. Ants appear to be important agents in carrying the conidia to the buds. No method of control has as yet been demonstrated.

Resting mycelia of Phytophthora and other related species. I. E. MELHUS

It has been shown by careful experiments that the mycelium in *Phytophthora* infected tubers can spread from the tuber into the sprouts when placed in a warm, saturated atmosphere, and that the stems of plants growing from such tubers may become infected from below upward. Such diseased plants are produced more readily in a saturated atmosphere at a comparatively high temperature.

It has also been demonstrated that the mycelium can function in a similar capacity in other species closely related to *Phytophthora*, namely, *Peronospora parasitica* on *Lepidium virginicum*, *Peronospora ficariae* on *Ranunculus fascicularis*, *Plasmopara halstedii* on *Helianthus divaricatus*, *Cystopus candidus* on *Capsella bursa-pastoris* and *Lepidium virginicum*.

Some rose anthracnoses. JOHN L. SHELDON

A report is given of some anthracnoses of wild and cultivated roses, one of which was rather serious in certain localities. It was found that this one could be controlled by removing the infected canes early in the spring. Asco-stages of each of the fungi were obtained; one of them resembled species of *Gnomoniella* while the others were more like what is commonly known as *Glomerella*.

The diseases of the sweet pea. J. J. TAUBENHAUS

This paper presents the results of further observations on the sweet pea anthracnose (*Glomerella rufomaculans* (B) Sp. & V. Sch.). The mosaic disease, and damping-off diseases due to *Rhizoctonia* and *Sclerotinia libertiana* are recorded for the first time as attacking sweet peas under glass, as well as out of doors. *Thielavia basicola* is recorded for the first time in this country as causing a root rot of sweet peas. A mildew disease of the sweet pea (*Erysiphe polygoni*?) is also recorded as troublesome to sweet peas under glass.

The black rots of the sweet potato. J. J. TAUBENHAUS

In describing the black rot (*Sphaeronema fimbriatum* (E. & H.) Sacc.) of the

sweet potato B. D. Halsted also recorded a Sclerotium stage of that fungus which invades the entire roots and reduces it to a charcoal. Careful observations and studies by the writer have definitely demonstrated that the Sclerotium fungus is not a stage of *Sphaeronema fimbriatum* but that it is distinct from the latter, and the name *Sclerotium bataticola* n. sp. is proposed, together with the name "charcoal disease." This rot may often attack a root which was previously infected by *Sphaeronema fimbriatum* or it may attack healthy roots independent of the latter fungus. A third rot due to *Lasiodiplodia* is also recorded and *Lasiodiplodia tubericola* was found to be an active parasite on sweet potatoes.

The possibilities of disease resistance in cabbage. L. R. JONES

The cabbage, under intensive and continual culture, suffers peculiarly from plant parasites which persist in the soil. Club root (*Plasmodiophora*), black rot (*Pseudomonas*), black leg (*Phoma*), and yellows (*Fusarium*) are examples of such which are combining to make cabbage culture unprofitable over large areas of high-priced land in southern Wisconsin. Of these diseases yellows is the worst. Experiments during the last three years have failed to discover any specific remedy. On the other hand, the possibilities of developing disease resistant strains are encouraging. Trials of the last two seasons show certain standard varieties to have some resistance, especially the Houser, but Wisconsin growers do not like this as a commercial type. In even the worst-diseased fields occasional plants escape and mature apparently healthy heads.

About 100 such plants were selected in 1910 from 3 different fields, representing different strains of Danish ball-head varieties of winter cabbage, using care to select the best commercial types. Seed was grown from these in 1911 and tested in 1912 on soil badly infected with the yellows disease. The progeny of every one of these selected heads showed a high degree of disease resistance. The average of all of the heads for each of the three strains was as follows: Strain W, 70 per cent lived, 44 per cent headed; Strain H, 86 per cent lived, 53 per cent headed; Strain B, 93 per cent lived, 68 per cent headed. In contrast with these, the best of the commercial strains of the various varieties tested, including the Houser, gave only 27 per cent heads. The above figures are averages of all resistant strains; the best of these made an even better showing, viz., 98 per cent lived and 93 per cent headed. These had all been selected as showing desirable commercial characters and they reproduced these true to type. Heads of the best of these strains have been saved and from them an abundance of seed should be secured next year for further trial and possible selection.

Mycosphaerella pinodes the ascigerous stage of *Ascochyta pisi*. R. E. VAUGHAN

Ascochyta pisi Lib. is associated with *Septoria pisi* West. and other fungi in causing serious damage to the pea crop of Wisconsin. *Mycosphaerella pinodes* (B. & Bl.) Johannis. was observed in the autumn of 1911 and 1912 on dead vines previously attacked by *Ascochyta*. In one case *Mycosphaerella* developed in the greenhouse on plants inoculated with *Ascochyta*.

On October 4, 1912, mature ascospores were obtained from *Mycosphaerella* perithecia on dead pea stems. Several of these were crushed in water and the spores stippled on leaves of a healthy pea plant which was then kept in moist atmosphere in the greenhouse. After five days characteristic brown lesions appeared, resembling in every way those caused by *Ascochyta pisi*. In ten days pycnidia with mature *Ascochyta* spores were obtained. This experiment has been repeated several times with *Mycosphaerella* spores from different parts of Wisconsin, with the same result in each case.

A single *Mycosphaerella* spore was removed from a drop of 5 per cent gelatin solution, by means of the Barber spore-picking apparatus, and transferred to synthetic

agar. The development from this spore was observed from day to day, and on the seventh day from inoculation the culture was found to have spores of *Ascochyta pisi*. In order to prove that these spores were capable of producing lesions on the pea plant, a suspension was sprayed over healthy plants, which were then placed in moist atmosphere. In this case, also lesions and pycnidia of *Ascochyta* were produced, while control plants remained normal.

These observations and experiments show that *Mycosphaerella pinodes* is the ascigerous stage of *Ascochyta pisi*.

Observations on the migration of Bacillus amylovorus in the host tissues. FRED A. BACHMANN

Published in full in this number.

Some successful inoculations with the peach crown gall organism, and certain observations of retarded gall formation. CLAYTON O. SMITH

Reference is made to the work of Dr. Erwin F. Smith and his associates in establishing a wide range of hosts for *Bacterium tumefaciens*. Certain hosts not previously reported as susceptible have been successfully inoculated at the Whittier (California) laboratory. A list of plants successfully inoculated is given. Thirty-five species and a number of varieties, representing eight families, are listed. Retarded gall formation is described on Angiers quince and on fig. The organism may live for as much as a year and a half within the tissues of the host without causing evident gall formation.

A botrytis disease of dahlias. MEL. T. COOK

The fungus attacks the roots in storage, causing a rot, and is especially severe in moist places, but is of no importance if the storage houses are reasonably dry and well-ventilated. When the rotting roots or cultures are allowed to dry gradually, the fungus produces sclerotia of various sizes. No ascospore stage has been found.

Conditions influencing infection of apple leaves by Gymnosporangium macropus. H. R. FULTON

Inoculation tests and observation on natural infection indicate that the individual leaf in its growth passes from a condition of immunity, due to its very young condition, to one of maximum susceptibility as it reaches something more than half its full size; with increasing age it becomes less susceptible, and finally immune. On twigs the infection occurs in zones of usually three to five infected leaves, in which there is a decrease in the amount of infection from the intermediate leaves upward and downward to those respectively younger and older at the time of infection.

Alternaria rot of apples. MEL. T. COOK and G. W. MARTIN

This fungus attacks several varieties of apples, but is most severe on the Jonathan. It gains admission to the fruit through the lenticels and causes small, shallow, dry rot spots. It fruits abundantly in culture, producing very characteristic spores. It is different from the blossom-end and core rot reported by Longyear from Colorado in 1905, and from the blossom-end and core rots found in New Jersey. The spores of the organism show numerous papilla-like markings.

The use of the green muscardine in the control of some pests of sugar cane. JAMES BIRCH ROBER

To be published in PHYTOPATHOLOGY soon.

A disease of peanut plants caused by Bacterium solanacearum. H. R. FULTON and J. R. WINSTON

The identity of the causal organism with the one producing bacterial wilt of tobacco was established by cross inoculations with strains of the *Bacterium* from

the two hosts, by reisolation and later reinfection of each host, and by comparison of cultural and morphological features and staining reactions.

Control of apple rust by spraying. N. J. GIDDINGS and D. C. NEAL

Published in last number of PHYTOPATHOLOGY.

Further cultures of heteroecious rusts. W. P. FRASER

This paper describes field observations and artificial infection experiments which show that five of the fern rusts belonging to the genus *Uredinopsis* are heteroecious, having their aecial stage on *Abies balsamea* (L.) Mill., the aecia being the white spored forms that have passed as *Peridermium balsameum* Peck. The species thus connected were:—*Uredinopsis struthiopteridis* Stormer, *U. osmundae* Magn., *U. phegopteridis* Arthur, *U. atkinsonii* Magn. and *U. mirabilis* (Peck) Arthur. The paper also describes infection experiments with *Pucciniastrum myrtilli* (Schum.) Arthur, which infected *Tsuga canadensis* (L.) Carr., thus confirming the life history as previously established by Dr. Clinton. *Melampsora arctica* Rostr. was also successfully sown on *Abies balsamea*, and *Melampsora medusae* Thum. was likewise successful on *Tsuga canadensis*, confirming previous work of the writer.

Some field experiments with the chestnut canker fungus. W. H. RANKIN

The average rate of growth of artificially produced cankers during the summer months was 1.88 cm. per month (four weeks). The conidia appeared about one month after inoculation. The perithecial stromata however were not formed until late in the summer even in the case of infections produced in the spring. Mature perithecia were common by the middle of November in all cankers produced by inoculations made even as late as August 1. Ascospores are ejected only when free water is present on the stromata. Mature ascospores can be found at any time during the year. They are shot out in vast numbers with every rain during the summer and are carried by the wind. Ascospores yielded 100 per cent infections. The water content of the tree, as observed in 1912, does not alter the susceptibility of the trees to the fungus. Slow growing cankers can be produced on certain species of oaks. *Endothia virginiana* Anders. & Anders. is not pathogenic on chestnut in New York State.

Cronartium ribicola and the proscriptio of Ribes nigrum. F. C. STEWART and W. H. RANKIN

Another severe outbreak of *Cronartium* on currants occurred at Geneva, N. Y., in 1912. Six nurseries and ten fruit gardens were affected. In one nursery almost every leaf was affected on 15,000 black currant plants. Apparently, the disease is established at Geneva, although no specimen of the *Peridermium* stage on pine has yet been found there. Probably, it is also established at other places in New York and in Massachusetts and Connecticut. Complete eradication of the disease is no longer possible.

Observations made during the Geneva epidemic convince the writers that in attempts to control the pine blister rust vigorous warfare should be waged against the black currant. Owing to its great susceptibility and its habit of holding its leaves until late in the season, the black currant is particularly dangerous as an agent in the spread of the disease. In the uredinal stage, *Cronartium ribicola* readily spreads from one black currant plantation to another over distances of 800 meters or more. State authorities should discourage the further planting of black currants by seeking out diseased plants and promptly destroying them. This policy will be pursued in New York. Compared with the white pine, the black currant is of small consequence.

Effect of the steam-formalin treatment on certain soil organisms. J. R. WINSTON

Soil infected with *Fusarium* from tomato, and *Rhizoctonia* from potato, was given the steam-formalin treatment, and soil with similar infection was steamed to determine the efficiency of the steam-formalin treatment. When the steam-formalin treatment was used, pathogenic organisms were killed in about one-half the time required by steam alone. Tomato plants were grown in the above treated soil to determine the presence or absence of the pathogenic fungi.

The small lettuce Sclerotinia, an undescribed species. IVAN C. JAGGER

In 1900 a fungus similar to *Sclerotinia libertiana* Fuckel, but producing much smaller sclerotia, was described by Smith from Massachusetts greenhouse lettuce. He concluded that the fungus was a form of *S. libertiana* which has lost the ability to produce the perfect stage. The characteristic small sclerotia have been grown in pure culture and from them have developed small apothecia. The disc of the apothecium is lined with a layer of 8-spored asci interspersed with paraphyses. The ascospores germinate readily on nutrient media producing cultures with small sclerotia, and having other characters identical with the original. The fungus appears to be an undescribed species of *Sclerotinia* clearly distinct from *S. libertiana*.

Agar culture of wheat as a means of seedling purification. D. G. MILBRATH

This paper is a partial report upon certain investigations upon root diseases of wheat conducted in the laboratory and in the experimental fields of the North Dakota Agricultural College during the years 1910 to 1912. The work is a continuation of similar work undertaken and directed by Professor Bolley during the previous years of 1908 and 1909. The purpose of the work is to ascertain, by pure cultures, the possibility of purifying seedlings of wheat or other cereals so that physiological, or other experiments, may be carried on with wheat plants known to be internally free from disease-producing organisms.

The Thielavia disease of violets. DONALD REDDICK

Thielavia basicola Zopf has been found doing very serious damage to violets in commercial and private houses. The roots become infected and are rotted off at the point of attack. The occurrence of the disease on the roots is usually manifest by the peculiar yellowing and slight curling of the foliage.

Runners and leaf petioles become infected abundantly and in this condition the disease is spoken of by growers as the black rot disease. When infected runners are used for cuttings the fungus is apt to spread to the young roots. As high as 50 per cent of the plants as they come from the sand may be thrown away on this account. Plants grown from diseased cuttings are dwarfed and bear an inferior quality of flowers, although the quantity may be even greater than from healthy plants.

A culture of the fungus obtained from a single germinating segment of a chlamydospore has been used for inoculation purposes and the disease has been produced by artificial inoculation, the period of incubation being from ten to twelve days. Chlamydospores are to be found developed externally, but in old lesions they can be found densely packed in the cortical cells or even in the cells of the fibro-vascular bundles.

Physoderma zeae-maydis Shaw in Illinois. J. T. BARRETT

No abstract.

A bacterial disease of the sweet pea and clovers. THOS. F. MANNS

A disease of the sweet pea in England popularly known as "streak," and which heretofore has been assigned to different causes, is demonstrated to be bacterial.

It is related to a disease of clovers and apparently of other legumes. Cross inoculation work has been positive between sweet peas and red clover, also infections have been produced on red clover with the organism from the different clovers, soy bean, several *Lathyrus* species and other hosts. The disease is characterized on the sweet pea by brown spots or streaks on the stems which kill the cambium. On the clovers the stems are blackened and the leaves spotted like bacteriosis of beans. Infection is by way of the stomatic openings. Extensive cultural and biological studies indicate this to be a new species to which is applied the name *Bacillus lathyr* Mann's & Taubenhaus.

Notes on some Nebraska potato diseases. E. MEAD WILCOX

No abstract.

Some laboratory conveniences for the pathologist. E. MEAD WILCOX

No abstract.

The brown-rot canker of the peach. R. A. JHLE

The brown-rot fungus *Sclerotinia "fructigena"* was found to be the cause of cankers on the limbs of peach trees. At first the lesions are slight depressions but soon become open wounds with copious gum flow. Later they become black and rough. The lesion increases in size from year to year. The cankers may be formed by the fungus growing back from a brown-rotted fruit through the fruit spur into the limb but ascospore infection of blossoms is thought to be the greater source of trouble.

Sclerotinia "fructigena" from several sources in the United States was used for inoculation purposes. Infection has occurred in all of the two hundred or more inoculations thus far made on limbs of all ages.

Notes on the fungus diseases of sugar cane in Porto Rico. JOHN R. JOHNSTON

The early literature on the sugar cane fungi of Porto Rico is very indefinite as to their identity. The writer has collected many fungi on cane, and some of the most important ones have been identified by experts. A list of the fungi is given, together with notes as to their importance.

Marasmius sacchari and not *M. plicatus*, is stated to be the most common sugar cane agaric in Porto Rico. *M. sacchari* was positively identified on living cane, on cane trash, on *Panicum barbinode* and on dead tissues of *Bromelia pinguin*.

Colletotrichum falcatum is found not only on cane, but apparently also on dead petioles of *Carica papaya*, accompanying another species of *Colletotrichum*. *Thielaviopsis paradoxa* causes a disease both of the sugar cane and of pineapples in Porto Rico. *Thyridariotarda*, *Nectria laurentiana* and *Spegazzinia unguis* are reported both on cane and other plants.

Melanconium sacchari and *M. saccharinum* are reported as common. Besides the preceding, practically all the important cane fungi of other countries are also reported. The important disease-producing organisms not yet found in Porto Rico are the cane smut, the rust, and the organism causing the yellow gumming disease.

The diagnosis of wilt diseases and the diagnosis of Ascomycetes from their conidial stage. H. W. WOLLENWEBER

Published in this number.

Helminthosporium diseases of barley in Wisconsin. A. G. JOHNSON

Three distinct diseases of barley, caused by as many species of *Helminthosporium*, were observed in Wisconsin during the past season. By the symptoms and characters of the causal fungi, these may be segregated as follows:

A. Light yellow to brown striae in the leaves; infection systemic.

1. Stripe disease caused by *H. graminum* Rabh.

B. Oval to oblong brown blotches in leaves; infection local.

2. European blotch disease caused by *H. teres* Sacc. (Spores cylindrical, rounded at ends, usually straight).

3. American blotch disease caused by *H. sativum* P.K.B. (Spores narrowly spindle-shaped, usually more or less curved).

Damping-off and root rot parasites of sugar beets. H. A. EDSON

This paper was a report of progress on work which contemplates a comprehensive study of the seedling and root rot diseases of sugar beets throughout the country. By carefully controlled inoculation experiments with pure cultures, four fungi have been shown to stand in causal relation to seedling troubles. These are *Pythium debaryanum* Hesse, *Aphanomyces levis* de Bary, *Phoma betae* Frank and a species of *Rhizoctonia* probably identical with the form described as *Corticium vagum* B. & C. var. *solani* Burt, though the perfect stage has not been observed. Two of these fungi, *Phoma* and *Rhizoctonia*, are also capable of producing decay in mature beets.

Phoma betae was invariably present on beet seed examined, but so far has not been isolated from the soil. The other species mentioned appear to be soil borne and were not found on seed. For the proper control of inoculation experiments with seedlings some form of seed sterilization is necessary. Among the chemicals tried with negative results are, hydrogen peroxid, hydrochloric acid up to full concentration for fifteen minutes, followed by lime water, sulphuric acid up to full concentration for one hour, followed by lime water, and formalin solution up to 2 per cent for various intervals up to one hour. A more satisfactory method which was employed in all the inoculation work consists of pasteurization as suggested by Peters.¹ The seed was soaked in water at 60° C. for ten minutes, cooled in water, dried on filter paper and after an interval of twenty-four hours again heated for ten minutes in water at 60° C., after which it was placed in sterilized soil and watered with disease-free water. Numerous strains of the several fungi secured from various sources were employed. Those enumerated were invariably recovered from the diseased seedlings obtained by inoculation and passed through from four to six additional generations of seedlings.

The stem rot or the Hawaiian "Iliu" disease of sugar cane. C. W. EDGERTON

Read by title.

To be published in Phytopathology soon.

Hop mildew in New York. F. M. BLODGETT

This disease, caused by *Sphaerotheca humuli*, has been destructive in the hop yards of New York State for the past four years. Its control was undertaken by means of dusting with flowers of sulphur. Although the mean temperature of New York State for the summer months is considerably below that at which sulphur is said to be effective, very satisfactory results have been secured even under the unusually cool conditions prevailing during the season of 1912.

Powdery or corky scab, Spongospora subterranea (Wallr.) Johns. and its occurrence in North America. H. T. GÜSSOW AND J. W. EASTHAM.

Published in full in this number.

C. L. SHEAR,

Secretary-Treasurer.

¹Über die Erreger des Wurzelbrandes. Arb. a. d. Kais. Biol. Anst. f. Land- u. Forstwirtschaft 8, Heft 2.

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SOME OBSERVATIONS ON PHYTOPATHOLOGICAL PROBLEMS IN EUROPE AND AMERICA¹

C. L. SHEAR

In order to understand and appreciate present phytopathological conditions and problems, a brief reference to the development of the scientific study of plant diseases may be appropriate. Plant pathology, unlike animal pathology, is an almost new subject of investigation. Germany, in this as in most scientific work, took the lead. Kühn² in 1858 published the first distinct treatise on plant diseases worthy of mention. Then followed the work of De Bary and Pasteur, who laid the mycological and bacteriological foundations for scientific work in plant pathology, or parasitology, which includes the major portion of the subject at present. Next came the work of Frank, Sorauer, and Kirchner in Germany; Prillieux, Cornu, and Millardet in France; and Berkeley, Plowright and Ward in England. In America, the pioneers, Burrill, Farlow, and Bessey, were beginning work along this line in the seventies. The present epoch in the development of American phytopathology dates from the establishment of the Section of Vegetable Pathology of the Department of Agriculture in 1886, twenty-seven years ago, and the work of Scribner, Galloway, and Smith. Few branches of science have made such wonderful progress in a quarter of a century.

In the early days the workers were few and scattered, and each was busy with his special problems, the solution of which has made possible the broader outlook and rapid advance of the past decade. The recent great development of science, pure and applied, throughout the civilized world, and the easier and more frequent communication between nations has brought about much closer personal, agricultural and general commercial

¹ Read before the American Phytopathological Society, Cleveland, Ohio, January 2, 1913. This was the second of three papers in the Symposium on International Aspects of Phytopathological Problems. The first of these by L. R. Jones on The Importance of Closer International Relations in Phytopathology, will soon be published in Science; the third by W. A. Orton on International Phytopathological Problems connected with Quarantine Legislation will appear in a later number of PHYTOPATHOLOGY.

² Julius Kühn. Die Krankheiten der Kulturgewächse, ihre Ursachen und ihre Verhütung. Berlin, 1858; 2nd unaltered edition 1859.

relations, and thus new phytopathological problems have been created as well as greater importance given to old ones. Plant parasites and diseases have no respect for political boundaries. The constant and increasing interchange of cultivated plants and their products between different countries has naturally resulted in many cases in greatly facilitating the distribution and spread of serious plant parasites into countries and localities where they were formerly unknown. Some of the most conspicuous and well known instances of the introduction of new pests are to be found among the insects, such as the San Jose scale, the codling moth, and the gypsy moth. There are, however, conspicuous cases of plant parasites also, as downy mildew of potato, asparagus rust, etc.

The United States, as the foremost nation at present engaged in the collection, study and dissemination of useful plants, and as a leader in research in phytopathology, is under peculiar obligations to increase our knowledge of plant diseases and to do all in her power to prevent their spread. The attention of the general public has only lately been forcibly called to this subject. The recent introduction of the white pine blister rust, the potato wart disease, and perhaps also the chestnut blight fungus, has served at least one good purpose by arousing the public somewhat in regard to the seriousness of the situation. The sooner we get a broader and more comprehensive view and knowledge of these matters and the various important problems involved, the better it will be for all concerned.

During the past season the writer had an opportunity to continue and extend his previous pathological studies and observations more carefully in the fields and laboratories of Europe, and also to discuss the subjects with various foreign pathologists and horticulturists. Our observations began at Naples, Italy, from which point we worked north through Italy, Switzerland, Germany, Holland, Denmark and Sweden, and also England and Scotland. Attention was devoted particularly to fruit diseases and their causal organisms, with a view to determining the identity, or otherwise, of American and European diseases and parasites, and also their relations, distribution and destructiveness.

The study at home of foreign literature and specimens cannot give one a satisfactory knowledge of pathological conditions in Europe or other foreign countries. Actual observation soon convinced me that we have no adequate conception of the situation and problems. This is not generally due to any particular fault on the part of foreign plant pathologists in describing their diseases and organisms, but to our lack of an exact knowledge of the various environmental, cultural and other conditions which must be understood and considered.

In order to bring out some of the most striking and important facts and questions involved it may be best to discuss some specific cases studied.

The diseases to be considered fall chiefly into two groups: (1) those severe in Europe, but less so in America; (2) those severe in America, but not so in Europe.

DISEASES SEVERE IN EUROPE, BUT LESS SO IN AMERICA

Some of the most striking cases in the first group are the brown rots of fruits, *Sclerotinia* (*Monilia*) diseases. In America these diseases appear to be confined mostly, so far as their economic importance is concerned, to the stone fruits, peaches, plums and cherries, attacking chiefly the fruit, but sometimes also the blossoms and twigs, especially in case of the peach and plum. Brown rot has been observed in this country but rarely on pomaceous fruits, as the apple, pear and quince. We were much surprised, therefore, to find in northern Europe, especially in Denmark and Holland, that the brown rot behaved in a quite different manner from anything observed in this country. We found the sour cherry trees, which had been infected through the blossoms, with the twigs and branches so seriously killed back that the trees had somewhat the appearance of pear trees suffering from a bad case of blight. We were told that this was a common occurrence. We also found that apples, pears and quinces were frequently attacked by brown rot, especially the fruit. Old *Sclerotinia* mummies of apples and pears were frequently found in most orchards. The blossoms and twigs were also attacked, but not so seriously as in the case of cherries, plums and peaches. At Zürich Dr. Schellenberg exhibited specimens of quince twigs which had been killed back from six inches to a foot by *Monilia*, and we were told that this was not an uncommon occurrence.

European pathologists have expressed the opinion that there are several species of *Sclerotinia* which attack fruit trees in Europe. Whether there are sufficient morphological differences to justify the specific separation of the organisms may be questioned. There is no doubt, however, about the great difference in the behavior of the brown rots in Europe and America. Since *Sclerotinia* occurs, occasionally at least, in America, on practically all the fruits mentioned, and is not restricted entirely to particular hosts, the European and American organisms would not seem to be separable on a host basis. The conspicuous differences are in the virility and behavior of the organisms in the two countries. Why these differences occur can only be determined by a very thorough study of all the factors involved in the problem. We are of the opinion that different climatic conditions may have much to do with the differences in behavior of these parasites, and it may be found that the species, variety or race which is so virulent on cherries, for example, in Europe does not occur in this country.

As already mentioned, our purpose in this paper is to point out some of the important international pathological problems which have impressed

us most. We are not prepared at present to offer any final solution for most of them and will only give such suggestions as have been derived from a general study of the questions. We hope to contribute something further toward the solution of some of these specific problems when we have had fuller opportunity to study the material and data collected.

Next to the brown rots, the *Nectria* canker of apple, pear and quince, which has been attributed to *Nectria ditissima* Tul., proved most interesting and remarkable. This *Nectria* canker of apples is said to have been observed in a few localities in America, e.g., North Carolina, New York, Canada, New Hampshire, and recently it has been reported from northern California; but it is more of a rarity at present than a disease of economic importance. The first cases of this disease we observed were in northern Italy and southern Switzerland, where the trees were in such a neglected and debilitated condition that they would have been an easy prey to almost any fungus. Farther north, however, in Germany, Holland and Denmark, we found an abundance of evidence that this fungus is a very serious menace to apple trees; in fact, certain varieties such as Red Astrachan and Cox's Orange Pippin are so badly injured by this canker that some growers have abandoned their cultivation. Even where careful attention had been given to cultivation, pruning, spraying, and the general treatment of orchards, these varieties especially were very badly injured. If the disease which has been attributed to *Nectria ditissima* in this country, is really caused by the European fungus the difference in its behavior in Europe and America is remarkable. It is more probable that the American fungus has been incorrectly identified. Doctor Seaver, who has recently studied the species of *Nectria*, expresses the opinion that the *Nectria ditissima* of American mycologists is the same as *Nectria coccinea* (Pers.). European mycologists have also recently stated that the fungus causing the apple canker in Europe has been incorrectly identified and is not *Nectria ditissima* Tul. but *N. galligena* Bres., a fungus which has not been reported from this country. It seems probable, therefore, that the true European *Nectria* canker does not occur here. If so, every possible precaution should be taken to prevent its introduction, as we have at present no canker disease in America which approaches it in destructiveness.

The silver leaf disease of plums and apples has recently attracted much attention in Europe and has been reported from America. Professor Brooks, of Cambridge, England, seems to have demonstrated beyond question that *Stereum purpureum* is able to produce this disease, but whether a similar effect may be produced by some other organism or cause is not known at present. Certain varieties of plums, such as Victoria, are particularly subject to this disease and are very seriously affected by it.

We had an opportunity to go over Professor Brooks' inoculation experi-

ments with him and there seems no way of escaping his conclusions. He admits, of course, that there may be other causes producing similar effects. Since *Stereum purpureum* is generally regarded by mycologists as a cosmopolitan species, and is found in most parts of the United States, the question arises why the disease attributed to it is not more frequently met with in other countries.

Again, the powdery mildew of strawberries is a rather serious disease in northern Europe, especially in England, whereas the same fungus supposedly occurs in this country upon the strawberry, but very rarely produces any serious injury.

The diseases thus far mentioned and the organisms producing them have been generally regarded as endemic in both Europe and America, and the differences in behavior in the two countries can not, therefore, be accounted for in the way usual with introduced diseases.

The powdery mildews of oak and of gooseberry, which have recently overrun Europe and are generally believed to have been introduced from America, are also very interesting and furnish excellent material for phytopathological study. Unfortunately, however, the history of their introduction and spread is not clearly established. The oak mildew has recently been described as a new species. Its appearance in Europe, however, is very similar to that of our common oak mildew in this country, which is regarded by some mycologists as identical with the mildew growing in Europe on certain other hosts. The fact that it rarely produces perithecia in Europe also suggests its foreign origin, as the powdery mildew of grapes, which is generally considered of American origin, behaves in the same manner. The existence of races and strains of the powdery mildews showing different degrees of parasitism on the same host, as well as on different hosts, has been shown by Salmon and Ward.

The difference in the behavior of the gooseberry mildew in Europe and America seems to be due largely to the European host being a much more susceptible plant than our American gooseberry, though climatic conditions are also, perhaps, involved. The same may be true of the oak mildew.

The black rot of grape, which is generally regarded as introduced in Europe, seems to affect the European varieties more seriously than the American under the same conditions, and this difference in susceptibility of species and varieties of hosts appears to be the primary cause of the difference in the severity of the disease.

DISEASES SEVERE IN AMERICA, BUT NOT SO IN EUROPE

We may now discuss briefly the second group of diseases, those which are serious and important in America but not so in Europe. The black rot of apple is a conspicuous example of this class. The fungus, *Sphaeropsis*

malorum, which causes the trouble, has been found in various parts of Europe, from Italy to England, though it is apparently not common and has sometimes passed under other names, as *Diplodia pseudodiplodia* Fekl. The fungus has been found on apple twigs and also on apples, the type specimens having been collected in England and described by Berkeley. The difference in the behavior of the organism in the two cases is, however, very remarkable. As is well known, the black rot of apple in America is a widespread and destructive disease, attacking fruit, foliage and branches, while in Europe it has never been reported as doing any noticeable injury in orchards. Here of course physiological races or strains of the organism, or possibly mistaken identity, may be involved.

What has been said of the black rot of apple is also apparently equally true of the bitter rot caused by *Glomerella cingulata* (Stonem.) S. & v. S. The conidial stage of this fungus, *Gloeosporium fructigenum*, was first found and described by Berkeley in England and has since been found in most other European countries. It has never been known to do any particular injury to apples there, whereas, in certain regions and seasons in America it is one of our worst apple diseases. There seems to be no doubt of the morphological identity of the organism in both countries and the striking difference in its behavior still remains to be explained. The work of Schneider-Orelli seems to indicate that there are physiological differences between certain American and European forms especially as to optimum temperature for growth.

The behavior of asparagus rust is also interesting. There seems to be no doubt of its introduction from Europe with its host. It does not usually cause serious trouble in Europe but is very destructive in this country. In this case climatic conditions seem to be clearly of primary importance. The higher night temperature in summer in this country, with accompanying dews, seems to favor the spread of infection by uredospores. Asparagus rust, in common with some other rusts, furnishes one of the comparatively few cases among fungus parasites in which other parasites may play a noticeable part in its control. *Tuberculina persicina* and *Darlaca filum* are both well known parasites of rusts, and in this case the latter may be of benefit in destroying the rust. I fear, however, we can hardly hope to demonstrate at present that such parasites are of sufficient importance to justify large appropriations for their introduction and dissemination.

When visiting Dr. Ferraris, the Italian pathologist at Alba, I was much interested in cultures and specimens of pear blight which he exhibited. The specimens were collected in Italy, but thus far the disease has attracted little or no attention, possibly on account of its recent introduction. In view of the rapidity with which this disease spreads when once established

in any locality in America, it will be interesting to watch its behavior in Europe. Dr. Ferraris seemed to have no doubt of the disease being due to *Bacillus amylovorus*, and his specimens of affected twigs certainly had the appearance of being killed by pear blight.

Many other examples of the difference in behavior of the same organisms in different countries and different regions might be cited from other fields of biology, such as the cases of introduced flowering plants, which in some instances rapidly overrun the country and become serious weed pests, while in their native homes they assume no such importance.

I was particularly struck with the fact, which is of course familiar to entomologists, that the codling moth, while a native of Europe, does not cause any very serious harm there. We were told by one of the largest apple growers in England that he did not find it necessary to spray or combat in any way the codling moth, as the amount of injury to the fruit was usually a negligible quantity. Parasites and other natural enemies of the insect are usually considered responsible for holding it in check in its native haunts, I believe. Whether this has been satisfactorily demonstrated or not I do not know. It seems probable that climatic conditions are also involved.

The all-important question which arises in connection with the diseases and organisms we have mentioned is, What are the specific controlling causes of the phenomena? Mention may be made of some of what appear to me to be the most probable and important factors concerned. First, perhaps, are differences in climate or other environmental conditions. Further investigations along this line, we believe, will throw some light upon these problems, and a careful study of this phase of the question should give profitable results. Americans, I think, do not usually appreciate the climatic differences between Europe and America. I doubt, for instance, whether most of us think of Naples as in practically the same latitude as New York City. The regions north of Italy differ chiefly in climatic conditions from those in the northern United States in their lower average summer temperatures and higher average winter temperatures. There are also, of course, great differences in the average and seasonal rainfalls and in general humidity. Closer co-operation between weather bureaus and meteorological observatories, and greater attention to the collection and publication of data, with special reference to botanical and pathological problems, would be of great assistance in throwing light upon some of these questions.

Another factor which is no doubt an important one in accounting for some cases is the existence of different varieties, races, or strains of a host plant, which even under the same conditions, show different degrees of susceptibility to the same disease. This is generally believed to account

for certain of the cases mentioned, especially the greater virulence of powdery mildew on European gooseberries than on American varieties, as it is found that the European varieties when grown in this country are also very seriously attacked by the disease. The behavior of our black rot and powdery mildew of grapes in Europe appears to be explained in the same way. Whether the chestnut blight is another case of this kind remains to be determined.

Studies in recent years have also apparently established the fact that there exist different varieties, races, or strains of parasitic fungi which show different degrees of virility or ability to produce disease, even under the same conditions and on the same hosts. These differences are usually of a physiological character and have not generally been coordinated with any distinctive morphological peculiarities. Whether the existence of these races or strains is the cause of some of the phenomena noted has not yet been satisfactorily determined, but a thorough investigation of this phase of the subject should be made by testing the European strains by carefully controlled inoculation experiments under American conditions.

Another explanation of some cases is probably to be found in a mistaken identification of the organisms involved, as was suggested in connection with the apple canker fungus, *Nectria ditissima*. This emphasizes the great necessity of a very thorough comparative study, both morphologically and physiologically, of the disease producing organisms of the different countries. This knowledge is of fundamental importance.

What has already been said seems sufficient to indicate something of the number and importance of the international problems confronting us and some of the chief lines of scientific investigation which should be vigorously pursued. This brings us to the question of our duties and privileges as a nation and as phytopathologists. Phytopathological problems are no longer local problems, but world problems, and the sooner we recognize and adopt this point of view, the sooner we shall be able to successfully attack them.

The present public interest in these matters, as indicated by legislation in regard to inspection and quarantine recently adopted in various countries, and especially the law lately enacted in this country, shows some appreciation of the dangers which threaten agriculture and horticulture from the spread of plant diseases and pests. From the standpoint of the pathologist, however, the chief attention at present should be given to a more thorough study and investigation of the fundamental scientific problems of pathology involved, as it is only by an understanding of these that measures of prevention and control can be practically and profitably devised. If the money which has been spent in attempts to eradicate diseases after they have been introduced into a country could have been spent

in thorough scientific investigation of the diseases and organisms and their methods of dissemination and means of prevention, much more satisfactory results could have been accomplished. These problems can only be studied to advantage by thoroughly trained pathologists with a broad knowledge of American conditions and diseases and adequate facilities for comparative field and laboratory studies in foreign countries. Such studies would greatly increase our knowledge of phytopathology and would furnish a sound basis for the formulation and enforcement of inspection and quarantine laws. No satisfactory laws or quarantine and inspection measures relating to fungus parasites can be adopted or satisfactorily enforced until our knowledge of these problems and conditions is greatly increased.

It does not necessarily follow that a disease which is virulent in Europe or some other foreign country will be equally serious or more so when introduced into this country, though we are of course amply justified in quarantining against such diseases. On the other hand, it is not safe to assume that a parasite which is of little or no economic importance in another country will not prove a serious parasite when introduced into this country. A great need at present is to discover some safe basis for predicting what the behavior of the parasite will be when introduced into any new locality. This might perhaps be done by making careful inoculation experiments with the foreign organism in this country under thoroughly controlled conditions, so that there is no danger of its spreading.

The inspection of seeds, plants, or nursery stock of any kind, as a means of detecting the presence of many of their fungus parasites, is almost useless, as it is well established that many of these organisms live in the tissues of the host or beneath bud scales, or in other protected places where their detection is practically impossible, and disinfection or destruction equally impossible, without destroying the host plant. In the case of insect pests detection and fumigation are of course much more effective. Since fungous parasites cannot be detected by inspection with any degree of certainty, and it is impracticable to quarantine against everything which may be dangerous, some other means must be found to prevent the dissemination of foreign fungous diseases. This we believe would be accomplished in the most effective manner by the plan which has been proposed of establishing quarantine stations where imported plants suspected of harboring parasites shall be grown under the observation of pathologists for at least one year before they are distributed. This provision we believe should be added to the present law. Attempts to eradicate parasites when once introduced have thus far been expensive and futile. An ounce of prevention in this case is worth many pounds of cure.

Let us consider briefly the chief existing agencies which may be utilized in extending and advancing international phytopathology and assisting

in the solution of the many problems, both scientific and economic, which confront us. The problems connected with inspection and quarantine, and legislative and administrative action for the prevention of the introduction and further dissemination of dangerous parasites can be most satisfactorily attacked by the closest co-operation between the departments and officials in the different countries and states having charge of the inspection of plants and the enforcement of laws relating thereto. The Consular Service might be utilized to some extent, perhaps, in this connection also. A careful, comparative study of the laws, regulations and methods employed in other countries might also be helpful.

The advancement of our knowledge of the scientific phases of phytopathology and the solution of its most pressing international problems can be promoted through various existing agencies, some of which have been already incidentally mentioned. We may call attention to the following: First, The International Institute of Agriculture at Rome, which has a Bureau of Agricultural Intelligence and Plant Diseases. This Institute was established and ratified by forty-eight governments and is supposed to have their active support and co-operation. It possesses great possibilities if properly supported financially and officially and conducted by a sufficient staff of competent pathologists. At present the bureau referred to issues a monthly bulletin devoting a small space to abstracts or reviews of current pathological literature, and occasionally containing a report from some government pathologist. The usefulness of this bureau could be greatly increased if it were possible to arrange, through the co-operation of all the governments concerned, to prepare and publish promptly abstracts, or mention at least, of all the phytopathological literature of the world, a thing which is not accomplished at present by any publication. There are a dozen or more publications giving partial lists of current pathological papers, but none is complete. One is compelled to look over most of these lists if he would keep in touch with the latest results of investigation in this field of research, but he can never feel reasonably certain that some important paper has not been missed. This would be an important step in the general conservation movement, also, as the dissipation of time, money and energy by all concerned is enormous, and the final results at present unsatisfactory.

Another agency which is not sufficiently developed or utilized at present is the Centralstelle für Pilzkulturen, conducted by Miss Johanna Westerdijk, Amsterdam, Holland, in connection with the International Association of Botanists and the Willie Commelin Scholten. The purpose of the work is to make available through purchase or exchange pure cultures of fungi, especially those which are pathogenic.

The interchange of professors of pathology with foreign countries would also bring about a better understanding of international conditions and problems, as well as of the pathologists themselves, and would tend to bring us into more intimate and sympathetic relations with each other.

The proposal to have foreign pathologists visit this country, study pathological conditions and give us the benefit of their European experience is an excellent one and certain to prove mutually beneficial. The organization of an international phytopathological society might also be a valuable means of securing more united effort and cooperation in the solution of our problems.

The appearance and rapid spread of the chestnut blight, as well as other diseases which have recently appeared in this country, have called forcibly to our attention the importance and necessity of securing more accurate information in regard to the origin, history and spread of pathogenic fungi and the conditions and factors involved in epidemics.

To summarize, then, we believe that the various facts cited demonstrate beyond question the necessity of a broader pathological outlook. Most phytopathological problems in ultimate analysis are international and to be most successfully attacked must be approached from that standpoint. Their solution can be most quickly and economically accomplished by close and active cooperation between the different governments and pathologists. Investigators should have the fullest facilities for observation and research wherever the problem leads, without reference to political boundaries.

The solution of the fundamental problems already discussed must, in great measure, precede the establishment of the most efficient means and methods for preventing or restricting the dissemination of pathogenic fungi.

THE USE OF THE GREEN MUSCARDINE IN THE CONTROL OF SOME SUGAR CANE PESTS

JAMES BIRCH RORER

WITH PLATE VII

The most serious problem which has confronted the scientific workers in the West Indies for the past five or six years is the control of the so-called blight of sugar cane in Trinidad, which is caused by the froghopper, *Tomasipis varia*, one of the Cercopidæ. The insect in its nymphal stage lives under ground and kills the roots of the cane by sucking, so that the plants stop growing, and, if subsequent weather conditions are unfavorable, gradually dry up and become a total loss, or, if the rains are plentiful, make a fresh start, but never recover the lost ground either in weight or in purity of juice. Up to the present no egg parasite or other active enemies of the froghopper have been found.¹ A predaceous bug has recently been imported from Mexico but it will take it many years to increase sufficiently under the most favorable conditions, so as to act as a successful means of control.

Another cane pest of considerable importance is the small moth borer, *Diatraea saccharalis* and allied species, which, though held in check to a considerable extent by natural insect enemies, still does a great amount of damage.

Yet a third type of pest in some of the Leeward Islands and Porto Rico consists of the larvæ of beetles belonging to the genus *Lachnosterna*.

Curiously enough all these insects belonging to widely different families are very susceptible to the green muscardine, an epizootic disease caused by the fungus *Metarrhizium anisopliæ* Sorokin, in consequence of which a study of this fungus, with special reference to the froghoppers, was undertaken. In a paper entitled *The Green Muscardine of Froghopper*, published in 1910,² the writer has already discussed the nomenclature of the fungus and its history in Trinidad, and has also given results of inoculation experiments in both the laboratory and the field, which prove conclusively that it is a very active and destructive parasite of the froghopper in the adult and nymphal stages.

¹ Since this paper was prepared an hymenopterous egg parasite has been found in Trinidad.

² Rorer, J. B. The green muscardine of froghoppers. *Proceed. Agric. Soc. Trinidad and Tobago* 10: 467-482. 1 plate. 1910.

More recent observations have shown that female froghoppers when once infected die before oviposition—a point of great practical value—while the larvæ of the moth borer and *Lachnosterna* beetles, when dusted with spores, succumb to the disease within a few days. When used as a means of control for any of these pests, especially the froghopper, spores are required in large quantities and much time has been devoted during the past six months to perfecting the method of growing the fungus in the culture cabinets first described in the paper already indicated.

About twenty-five cabinets are now in use on various estates and give very good results if properly cared for. The unit cabinet is a box approximately 3 feet square and 6 feet high lined with galvanized iron, with a steam pipe running down through the center, and containing a number of galvanized shelves. About 3 inches above each shelf, on either one of the sides or the back, it is immaterial which, two holes $\frac{1}{2}$ inch in diameter are made through to the outside and fitted with galvanized tubes $1\frac{1}{2}$ inches long which are soldered to the galvanized lining and plugged with corks on the outside. The cabinets are inoculated through these tubes. The central steam pipe is soldered to the lining at top and bottom and has six or eight very small perforations, not more than $\frac{1}{16}$ to $\frac{1}{32}$ inch in diameter to allow steam to enter the cabinet. A valve must be placed on the lower end of the pipe outside the cabinet to allow condensation water to escape, while the water which collects within the cabinet itself can be drawn off through a small tube placed in the bottom. The door is grooved to match a tongue on the cabinet and the groove is partly filled with cotton, which has been soaked in a solution of mercuric chloride and dried, making a tight, antiseptic joint. It is necessary to have several glass panels in the door, since the fungus seems to produce spores more quickly in light than in darkness. The glass is protected with sheets of asbestos during sterilization. The door is fastened in place by bolts (plate VII, figs. 1, 2, and 3).

The cabinet or series of cabinets should be located in as clean a place as possible; a specially built room is preferable, but is not necessary. Live steam for sterilizing is essential. In crop time on a cane estate this may be had from the large boilers, but out of crop there is generally a small boiler in use to run the engine for curing sugar, or for the workshop, from which steam may be obtained; 30 to 40 pounds pressure is all that is needed.

The method of operating a cabinet is as follows: About 40 pounds of rice is thoroughly washed and boiled for ten to fifteen minutes, either in a kettle over a fire, or, better and more quickly, by allowing live steam to escape from perforated cross pipes in the bottom of a pot or half-barrel in which the rice, with the required amount of water, has been placed. The cooked rice should be drained dry and while still hot spread in a layer about $\frac{1}{4}$ inch thick over all the shelves in the cabinet. The door is then

immediately put in place and steam turned on. A thermometer in a cork may be inserted in one of the inoculating holes and a temperature of 100°C. maintained for an hour. This sterilization is repeated on three or four successive days, care being taken that the steam valve is tightly closed after each heating, so that the cabinet will cool down thoroughly. It is then ready for inoculation.

Spores in sufficient quantities for inoculating cabinets can be readily obtained. At the beginning single spores should be cut out from petri dish cultures and transplanted to potato cylinders made and sterilized in the ordinary way except that no water is added to the tubes, so that the medium will be fairly dry. The fungus spreads very slowly at first but soon produces spores in the central part of the growth. In order to hasten the culture these spores may be spread all over the surface of the potato cylinder with a sterile needle. They will soon germinate and within two weeks a moderately thick crust of spores will be found over the whole cylinder. Spore crusts from about ten to fifteen cultures are loosened with a sterile platinum loop or needle and turned out into a sterile tube, which is then plugged with sterile cotton.

For inoculating purposes a 50 cc. Erlenmeyer flask, which has been previously sterilized in a hot oven, is used. The flask is fitted with a cork and glass tubes somewhat after the fashion of a chemical laboratory wash bottle, except that the outer end of the discharge tube is not drawn to a point and the inner end is just flush with the bottom of the cork. The spores are emptied into this flask. An atomizer bulb with a piece of sterile cotton tied over the intake valve is attached to one tube while the other is inserted in turn into each of the holes in the cabinet and a charge of spores blown in quickly by a slight pressure of the bulb. If the inoculating is thoroughly done as soon as the cabinet has cooled down after the last sterilization, the whole surface of the rice should be covered with the white felt-like mycelium of the fungus within three or four days, and spore production will be at its maximum (in tropical temperatures) after two or three weeks. The cabinet is then ready for opening. As the shelves are taken out they are dusted over thickly with cassava starch or flour and the whole mixture is gradually brushed off the tray with a moderately stiff brush, such as a scrubbing brush, or better, a white wash brush with the bristles cut off to about half length, on to a rectangular sieve about three feet long and 1½ feet wide. By shaking or stirring with a brush the starch and spore mixture will pass through the sieve and after a little more dilution with starch or flour is ready for use, while the residual rice can also be kept for spreading about the cane fields. A cabinet with ten shelves about 3 feet square should give at least 70 pounds of the spore and starch mixture, while there will be about one-third of a barrel of rice.

Although many cabinets give absolutely pure cultures of the green muscardine fungus it is not advisable to use spores from this source for inoculating other cabinets, since impurities from the air, especially if the cabinets are located near a sugar mill, are almost sure to get in, and will quickly overrun the rice before the right fungus gets its foothold. In Trinidad the writer supplies all the planters who have cabinets with pure spores for inoculating purposes. The spores are obtained from potato cylinders, as already described, and in part from cultures made in petri dishes. A flour and water mixture is made just thin enough to pour. About a dessert spoonful is put into each of a number of petri dishes which are tilted in all ways till the bottoms are covered. These are sterilized in an autoclave at 110°C. for ten minutes, or in a steamer on four successive days. They are inoculated by slightly raising the cover and blowing in spores from the flask inoculator already described. Potato cylinders or other media in tubes can also be inoculated by means of this blower. With a boy to remove and replace the plugs one can quite easily inoculate one hundred tubes in ten minutes, and if the work is done in a culture room there need be no fear of impurities. The writer has made over fifteen hundred tubes this year without a single foreign organism getting in.

Spores will be formed on the flour paste in about two weeks, and can be brushed off with a small sterile brush into a clean sterile petri dish and transferred later to sterile cotton-plugged tubes. The flour petri dishes will continue to produce "ratoon" crops of spores for two or three weeks, and if the successive productions are taken off in a clean culture room there need be no fear of contamination. One such culture will give enough spores to inoculate several cabinets.

Many different ways of using the fungus in the field have been tried and two have proved successful this year in starting epidemics of the disease. The first may be called hand infection, and works well where the infested area is more or less limited in extent. A number of boys with tubes containing spore-bearing cultures walk through the cane fields and wherever they see a frog hopper resting on a leaf they catch him in the tube and then let him jump out again. Ten or twelve boys can cover a fairly large area in a day. The infected insects soon die and within a week or ten days the fungus is fruiting on their bodies so that they become a source of infection for others. In this way the fungus has been well established on one or two of the small estates.

Spreading the spores with dusting machines is the method which has given most success in the treatment of large areas, and this is essential in dealing with the frog hopper. Machines of the Kansas City "Cyclone" type have been used with good results and the "Furet," a French apparatus, is also well adapted for the purpose. The spores should be applied at the

rate of 2 or 3 pounds to the acre so that the product from one culture in a cabinet should cover from 20 to 25 acres.

The first field treated this year (1912) was one of 20 acres on Orange Grove estate. The dusting was done during the first week in August, and actual counts in this field made by Mr. Urich, Entomologist of the Board of Agriculture, six weeks later showed an average of 92 dead insects per cane stool or about 184,000 per acre, and infection was still going on.

During the coming season every effort will be made to start an epidemic as early as possible after the rains begin, with the hope that the first brood of froghoppers may be kept down to the minimum.

BOARD OF AGRICULTURE

PORT-OF-SPAIN, TRINIDAD, B.W.I.

EXPLANATION OF PLATE VII

FIG. 1. Cabinet closed ready for sterilization. This cabinet contains ten shelves.

FIG. 2. Cabinet opened with shelves removed. The inoculating holes are in the back. The cock at base of steam pipe allows condensation water to escape.

FIG. 3. Cabinet opened showing rice covered with pure growth of green muscardine. In this cabinet the steam pipes run along the sides and are joined under each shelf by a cross pipe. This arrangement has no advantage over the central pipe and is more expensive.

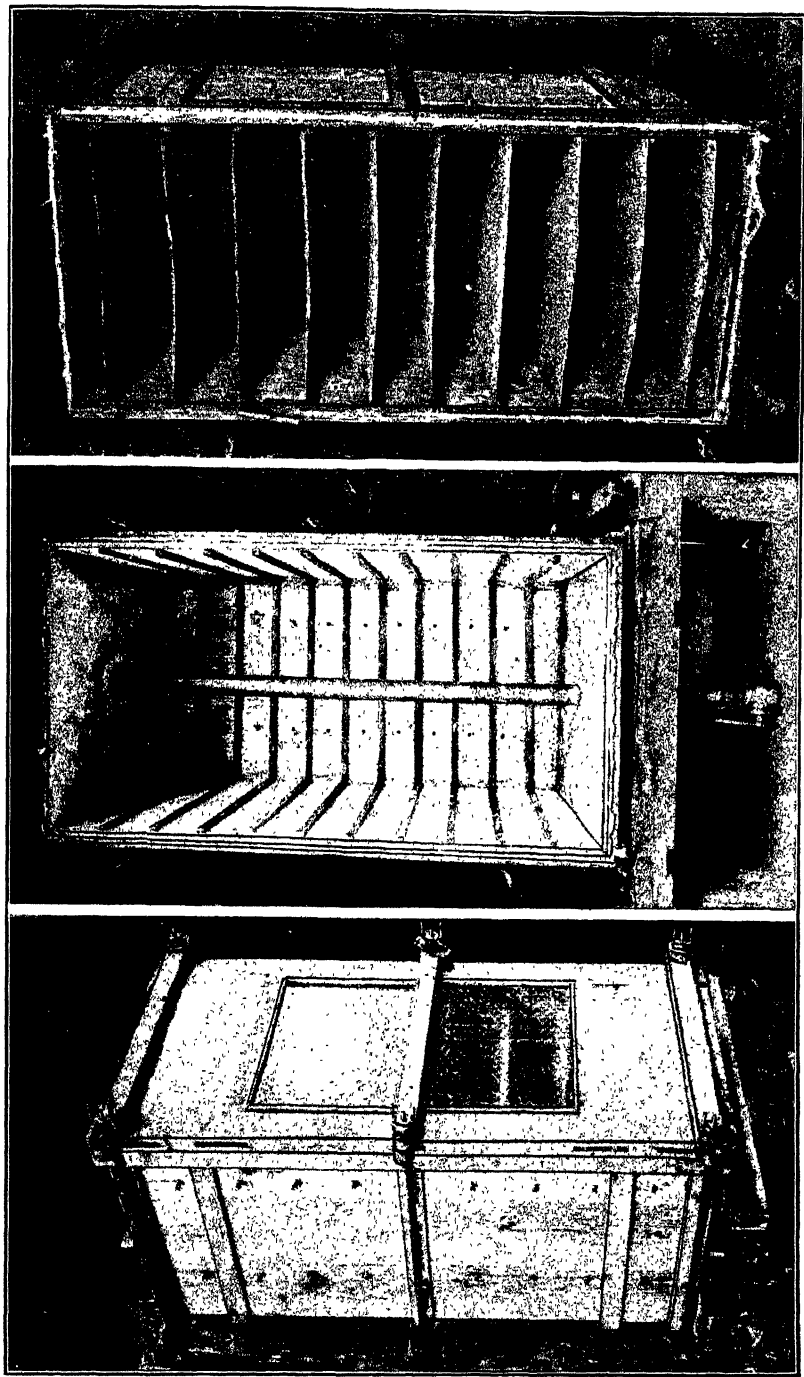


PLATE VII. CULTURE CHAMBERS

THE STEM ROT OR HAWAIIAN "ILIAU" DISEASE OF SUGAR CANE

C. W. E D G E R T O N

WITH PLATE VIII

During the past two years there has been under observation in Louisiana a serious disease of sugar cane caused by a fungus of the genus *Gnomonia*. The disease was first noticed in West Baton Rouge Parish in the summer of 1910 but has since been seen in other parishes in the central and northern parts of the state. The general appearance of the disease resembles in a way that caused by the root rot fungus, *Marasmius plicatus*, and it is possible that the two have been confused in the past. Until recently it was thought that this disease was new and perhaps confined to this country, but there has appeared a bulletin¹ from the Hawaiian Sugar Planters' Association which either describes the disease or one very similar to it. In this bulletin, the causative fungus is described as a new species, *Gnomonia iliau*. While the Hawaiian fungus as described by Lyon differs slightly from the Louisiana material as will be mentioned later, it is probable that the two are the same and the latter will, at least for the present, be considered as *Gnomonia iliau*.

The disease does considerable damage in the state, especially in the northern portion of the sugar cane belt. It does not seem to cause as much injury in the southern part of the state where the most of the cane is grown, though from reports of sugar planters it probably occurs in that region. This agrees with Lyon's statement concerning the disease in Hawaii as he says that the disease is only severe in the cooler regions of the islands, or during a cool season when the cane is not able to survive the attack.

The fungus attacks the cane in all its earlier stages of growth and then remains upon it during the rest of the season. It more frequently attacks the stalks in the spring before they begin to joint. If the cane is attacked early and the season is favorable to the disease many of the stalks remain small and often die, and many of those that live will not reach a height of more than one to two feet during the summer. If the attack is not so severe or the season is more favorable to the cane, the stalks joint and attempt to outgrow the disease. Some of these stalks will live through the season,

¹ Lyon, H. L. Iliau, an endemic cane disease. Hawaiian Sugar Planters' Association, Pathological and Physiological Series, Bulletin 11. 1912.

and though they are generally small, will be cut at grinding time, while others will finally succumb. The rot in the lower joints causes the stalks to weaken and finally they break off near the surface of the ground and fall over.

If the small stalks are examined, it will be found that all of the leaf sheaths near the ground are firmly cemented together by the fungus mycelium. The sheaths are dead and also the blades of all of the lower leaves. A few green leaves will be seen protruding above the dead mass of leaf sheaths at the base. If the sheaths are pulled apart a dense layer of white mycelium will be seen between them (fig. 3). The fungus often fruits on these small stalks, though perhaps not so abundantly as on the larger ones.

On jointed stalks that are diseased the lower leaf sheaths are cemented closely to the stalk and the white mycelium is abundant between them, as well as within the tissues (figs. 1 and 2). Many of the blades of the lower leaves are dead and the living leaves at the top often have a yellowish appearance and are close together, forming a loose tuft. The lower joints of a diseased stalk, underneath the dead leaf sheaths, are shorter than normal ones and also are often much less in diameter than the joints above the diseased portion. The mycelium not only attacks the leaf sheaths but also enters the rind tissue so that often the sheaths are quite firmly cemented to the stalk itself. The fungus gradually works through the rind and in towards the center of the stalk, though the progress inward is not rapid. The tissue is turned to a red color as the disease passes towards the center. If a diseased stalk is cut across one sees on the outside the layer of dried and shrunken leaf sheaths, then the dead, and slightly discolored rind tissue, then a ring of red parenchyma tissue, and finally on the inside a cylinder of uncolored, perfectly healthy parenchyma tissue. The killing of the rind tissue weakens the stalks and many of them fall or are blown over by the wind.

As can be seen, this disease resembles the root rot disease in that the leaf sheaths are firmly cemented together with the white mycelium. However, the latter disease does not pass into the rind tissue, and in this way it can be readily distinguished. Furthermore, the leaf sheaths do not pull apart as readily when they are attacked by the *Gnomonia* as they do when affected with the *Marasmius*, and also there is the lack of the mycelial strands which are often present with the root rot disease. In the *Gnomonia* disease there is a whitish to grayish mat of mycelium both within the tissues of the leaf sheaths as well as between them, while with the root rot the mycelium is seen mostly between the leaf sheaths. The sheaths are more severely rotted by the *Gnomonia*, the mycelium taking the place of the leaf tissue.

The *Gnomonia* fruits abundantly on the dead leaf sheaths, especially towards the fall of the year on the larger jointed stalks. Two stages of the fungus are present, the imperfect, which perhaps belongs to the form genus *Melanconium*, and the ascogenous, the latter being the more abundant. In the late summer or fall, nearly every stalk affected with the disease will be seen to be covered with the perithecia. This differs from the condition described by Lyon in the Hawaiian Islands. He states that the perithecial stage is not often seen and was not found until after the disease had been studied for some time. In Louisiana the perithecia were the first to attract attention, and it has always been easy to find them, while the *Melanconium* stage has not been so abundant. In fact, until some conidial pustules developed in cultures this stage was not known. Since then, however, a few of them have often been found on stalks in the field and many have been seen on inoculated plants in the greenhouse (fig. 2) and on inoculated stalks in moist chambers.

The imperfect stage (fig. 2) either develops in the outer leaf sheaths or in the more deeply covered ones. One can pull off the outer ones and see the small pustules that have developed and forced their spores out between the sheaths. Lyon states that this stage belongs to the form genus *Melanconium* and describes it under the name, *Melanconium iliau*. It may be as well to consider it as a *Melanconium*, although the fruiting pustules are not typical of this genus. Instead of the spores being borne in open pustules or acervuli they are usually in well developed pycnidia as shown in figure 4. These pycnidia are imbedded in the leaf tissue, generally with but a pore at the top, though occasionally the apex may be prolonged into a well developed beak. While most of them are quite regular in shape, being more or less subglobose, rather irregular pycnidia are frequently seen. There are often irregularities in the conidiophore-bearing tissue in the shape of protuberances or flaps which extend up into the pycnidial cavity, these sometimes producing almost a chambered condition. At the time the pycnidia develop the leaf is so badly decayed that they are more imbedded in the fungus tissue than in the leaf tissue (fig. 4). They are usually about 500-700 μ in diameter and quite thin walled. The spores, which are borne singly on the conidiophores, are very dark brown in color, elliptical to oval, coarsely granular, 7-10 x 15-28 μ . If they develop in a moist place they ooze out of the pycnidia in inky-black, slimy strings (fig. 2), but if they develop in a dryer place they merely form a smutty covering over the leaf sheath.

The perithecia develop very abundantly over the surface of the exposed dead leaf sheaths and give the stalks a very characteristic appearance (fig. 1). The beaks extend for some distance from the surface and are very hard; in fact when the finger is drawn over the surface of the stalk it is

like drawing it over a sharp file. The perithecia (fig. 5) are perfectly typical of the genus *Gnomonia*, about $325\text{--}480 \times 240\text{--}340\mu$ in size, and with a beak about $350\text{--}550\mu$ long. The asci are clavate, thin walled, $60\text{--}80 \times 8\text{--}14\mu$, and have a well developed pore at the apex. The spores are divided into two equal cells, hyaline, generally slightly curved, often slightly constricted at the septum, $22\text{--}30 \times 5\text{--}7\mu$.

In describing the Hawaiian material, Lyon says the asci are $55\text{--}60 \times 8\text{--}12\mu$, the ascospores $20\text{--}25 \times 3\text{--}5\mu$, and the spores of the imperfect stage $15\text{--}22 \times 6\text{--}8\mu$, these all being slightly less than the corresponding measurements of the Louisiana fungus. Specimens have been received from Dr. Lyon and examined and there seems to be no doubt but that there is a small difference in the measurements of the fungi as they occur in the two countries. The larger size of the spores and asci, and also the fact that the perithecia develop very abundantly in Louisiana and only occasionally in the Hawaiian Islands, seem to be the only differences between the fungus as it occurs in this country and in Hawaii. On account of the similarity of the two in other respects, it seems very doubtful if these are real differences.

The fungus has been cultured a number of times from the conidia and ascospores and also by making direct transfers from the diseased tissues. It grows readily in pure cultures, producing a dense white mycelium. The conidia develop on special media such as oat juice agar, but the perithecia seem to require the host plant for their development.

A number of inoculation experiments have been tried during the past two years in order to prove that the fungus was the cause of the disease. Mycelium from pure cultures, or spores direct from diseased cane, have been inoculated into healthy stalks both in the greenhouse and in the field. When young plants were used a good development of the disease always followed, but when large, jointed stalks were inoculated the disease was not produced. It would seem that the fungus must be firmly established in the leaf sheath tissue before it can attack the rind tissue of the stalks.

While studying the disease it seemed very probable that much of the trouble in the field came from planting infected seed stalks. In order to prove this diseased stalks, and also healthy stalks which had the spores of the fungus sprayed upon them, were planted in pots in the greenhouse. In practically every case the young plants that grew from these stalks were badly diseased. In most cases the young plants died after they reached a height of from 2 to 12 inches. An examination of these dead plants always showed the leaf sheaths to be firmly cemented together with the fungus mycelium, similar to the plants found in the field.

In a previous paragraph attention was called to the fact that the disease seems to do more damage in the northern part of the state than it does in the southern and it may be well to explain the probable reason for this.

Lyon states that in the Hawaiian Islands the disease is naturally more severe in the cooler regions, and this may be one of the factors in Louisiana, but it is not the only one, and probably not the one of most importance. The real cause seems to be in the methods of saving and planting cane as practiced by the farmers in the different sections. In the northern part of the state the planters put their cane down in beds during the winter to keep it from freezing. Since there are many stalks in contact, disease present on any of them has an excellent opportunity to spread to others in the bed, and by planting time many of the stalks have the fungus in various stages of development. These stalks, when planted, naturally produce diseased plants. In the southern part of the state, where the most of the cane is grown, the farmers either plant directly in the field in the fall or else wind-row the cane until spring. With either of these methods there are not many stalks in contact and there is but slight chance for the disease to spread from stalk to stalk, and where these are used the sugar cane is not severely damaged by the disease.

LOUISIANA AGRICULTURAL EXPERIMENT STATION
BATON ROUGE, LOUISIANA

EXPLANATION OF PLATE VIII

FIG. 1. A large stalk of sugar cane affected with *Gnomonia iliaui*, showing the leaf sheaths still surrounding the stalk and the abundance of perithecia of the fungus.

FIG. 2. A stalk of cane affected with *Gnomonia iliaui*, following inoculation with pure culture, showing the pustules of the imperfect stage of the fungus.

FIG. 3. A stalk of cane badly affected with the disease. The outer leaf sheaths have been stripped off and the white mycelium of the fungus is visible.

FIG. 4. Photomicrograph of perithecium of *Gnomonia iliaui*. $\times 67$.

FIG. 5. Photomicrograph of the imperfect stage of *Gnomonia iliaui*. $\times 67$.



GNOMONIA ILIAU

PLATE VIII STEM ROT OF SUGAR CANE

JONATHAN FRUIT SPOT

J. B. S. NORTON

It may be of interest to those who are working with this recently described¹ disease of apples to know that the same condition can be practically duplicated by the action of certain gases. It was noticed last autumn that apples and pears fumigated with small amounts of formaldehyde developed under the lenticels the small black spots which characterize the Jonathan spot. Several varieties of apple and Keiffer pears were then placed under bell jars and a few drops of ammonia or formaldehyde added in watch glasses, with suitable checks of a similar nature without the ammonia or formaldehyde. Although no very extensive investigations were carried out, it was found that one drop of ammonia to about four liters of space would produce the spots over night.

The spots appear light brown at first, and in some varieties remain so for a long time and are often inconspicuous. In red varieties (Arkansas Black and Jonathan), the black color develops in a day or two after the injury. It also comes out quickly in pears, giving very dark spots in a few hours. If the fruits are kept in a moist atmosphere pitting does not take place soon, but when calcium chloride is kept under the jars, the spots soon appear sunken.

Some varieties seem much more sensitive to the action of the gases, the Jonathan proving particularly so as compared with the several other varieties tried. In these experimental apples, as well as those of spotted Spitzenburg and Jonathan taken from storage in Washington, there is nearly always a distinctly unaffected area around the calyx. Some badly pitted apples taken from cold storage had a very conspicuous ammonia-like odor in their paper wrapping, which suggested the idea that ammonia from the cooling apparatus might be a common cause of the Jonathan spot. While inquiry among men familiar with cold storage work revealed a number of cases where ammonia leaks had caused fruit-spotting, it is not probable that any great amount of damage is done in this way, since, with the usual modern methods of cold storage, there is little opportunity for ammo-

¹ Scott, W. M. *Phytopathology* 1: 32-34. 1911. Scott, W. M. and Roberts, J. W. U. S. Dept. Agr. Bur. Pl. Ind. Circ. 112. 1913. Mentioned also by Beach and Clark, N. Y. Agr. Exp. Sta. Bul. 248: 300. 1904.

nia to reach the fruit, and also it is well known that the spot may appear on the fruit while yet on the tree.

A somewhat similar effect of sulfur fumes on Spitzenburg apples has been reported.²

MARYLAND AGRICULTURAL EXPERIMENT STATION
COLLEGE PARK, MARYLAND

² Eustace, H. J. N. Y. (Geneva) Agr. Exp. Sta. Bul. 297: 135. 1908.

SOME OBSERVATIONS ON POLYPORUS BERKELEYI

JAMES R. WEIR

WITH PLATE IX

Numerous references are found in the literature regarding the proximity of *Polyporus berkeleyi* Fr. to the base of trees, either in contact with, or between the large spurs of the roots, or in connection with buried wood of some sort.

In the east the tree is said to be usually an oak and the writer has collected it under oaks in the Carolinas. That the oak association may change to one of beech in Indiana and larch in Idaho certainly shows a much wider range for this fungus, in two ways, than heretofore reported. The peculiar and highly interesting affinity the fungus exhibits for particular species of trees in different sections of the United States is not always easy to explain. Probably the wide-spreading crown and buttressed roots of the oak and beech furnish a more favorable protection for the best growth of the fungus than some other forest trees. The depth and quality of the forest mold, through which a portion of the mycelium always ramifies, even if the fungus is attached to a woody substratum, may be greater and the moisture content more uniform. Certainly, the thickness of the mold and the constant moisture conditions surrounding the root system of certain forest trees are some of the main reasons for their selection by this fungus. Such conditions would materially aid any saprophytic or parasitic tendencies a root fungus might possess by promoting an increased vegetative activity.

During the past summer the writer has made extensive collections of *Polyporus berkeleyi* in the forests of Montana and Idaho, where it is very common, always occurring at the base of larches; and in point of size it frequently rivals any of the dimensions so far given in the literature. Its constant association with the western larch (*Larix occidentalis*) is of interest inasmuch as numerous observations show the fungus to have the ability to spread its mycelium as a wound fungus in the wood of the root spurs which have been weakened or opened up by fire or through the attack of pine squirrels or some burrowing animals which frequent the thick deposits at the base of the trees. The depth and extent of this débris about the roots of old larch trees is favorable for, and affords much protection to, the vigorous mycelium always produced by this fungus. The deposit, consisting of the materials of the outer bark and the annual leaf fall, which usually,

owing to the narrow crown of the larch, collects at the base of the tree, forms a mound of considerable thickness, often two or three feet deep. Moisture collects in this material to such an extent that it is not easily destroyed by surface or ground fires and the fungus continues to spring from a perennial mycelium year after year and the materials become matted about the roots in one compact mass.

The sporophores usually spring from the deepest-buried root spurs and in order to bring the pileus into the open a long stipe or "root" is developed, the length depending upon the depth of the mound about the tree. Figure 1 shows a sporophore with a stipe some 10 inches in length which was directly attached to an area of diseased wood extending longitudinally along the root spur and continuing into the living wood above in finger-like streaks. Sporophores may appear some distance away from the base of the tree but the felted mat of mycelium can be traced deep into the mound about the roots and will be found to be in connection with some of the smaller lateral roots of the main spurs (fig. 2). These smaller roots are frequently entirely diseased and the mycelium of the fungus is found ramifying throughout the decayed wood (fig. 4) from which it is possible to grow a sporophore when the wood is buried in the forest mold in a part of the forest from which the fungus has not been collected. The decayed wood from both smaller and larger roots exhibits a stringy white appearance, the primary cell wall materials remaining intact longest. In the early stages of the decay the annual rings separate, owing to the greater activity of the mycelium in the spring wood.

There is no evidence forthcoming that the mycelium has the ability to attack living wood. But on the contrary, it appears to extend into and decay wood of trees killed by fire in early life. Since wounding the peripheral wood causes extensive areas in the longitudinal axis of the root to become dead or functionless, the mycelium of the fungus invades these regions and eventually brings about the white rot already indicated and becomes more or less permanently established, both in the wood and in the deposits about the base, as the tree increases in age. The sporophores are larger and greater in number the older the tree becomes.

It will be noted in the illustration that the stipe is very irregular in contour. This is partly due to the obstruction it has encountered in the mass of materials through which it has passed, also, to a natural lateral regeneration induced by contact with moist woody substances in the mound about the tree. It has been determined that the mycelium composing the basal part of the stipe or "root" remains active after the sporophore dies and that it may be the source of a new sporophore the following year, or, in case of its premature destruction, it may regenerate another the same year (fig. 3).

Polyporus berkeleyi has always been of interest to the mycologist, owing to its large size—the largest of the stiped polypores in the United States—and its echinulate spores. Its common occurrence throughout the forests of northern Idaho and its evident saprophytism on the roots of the western larch seem of sufficient interest here to merit this short account.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY

U. S. DEPARTMENT OF AGRICULTURE

MISSOULA, MONTANA

EXPLANATION OF PLATE IX

Fig. 1 Sporophore showing long root-like extension of the stipe. The mycelium supporting this sporophore extended throughout the dead wood of a wound of a living root spur of *Larix occidentalis*.

Fig. 2 Sporophore from a small root of the main spur, *Larix occidentalis*. A portion of the root was still living. The mycelium had extended a distance of 2 or 3 feet in each direction.

Fig. 3 Basal section of a stipe or "root" 15 inches long regenerating a small sporophore.

Fig. 4 Longitudinal sections of roots of *Larix occidentalis* decayed through the action of the mycelium of *P. berkeleyi*. The black lines show extent of mycelium in the wood.



PLATE IX POLYPORUS BERKELEYI

THE BROWN ROT CANKER OF THE PEACH

R. A. JEHLE

WITH PLATE X

During the summer of 1911 and 1912 the writer investigated a canker which was prevalent in Niagara County, New York. A large number of peach orchards within a radius of about ten miles of Newfane were visited and many cankers were found in some of them, while in others there were relatively few. In one orchard, containing about two thousand trees, almost every tree had from twenty-five to fifty cankers (plate X, fig. 1), and none of the orchards visited were absolutely free. The varieties chiefly grown in that region are Elberta, Early Crawford, Late Crawford, and Early St. John. All seem to be very susceptible to the disease, but the Elberta appears to suffer more than the other varieties.

Cankers were found on limbs of all sizes, from those of the second year's growth to those of the larger main limbs, but they were most prevalent on limbs about one to two inches in diameter. The first symptoms of the canker are a sinking of the tissue just beneath the bark, followed by the formation of a gum pocket in this sunken area. Later, the bark cracks and splits and the gum oozes out as a sticky mass. A callus is soon formed outside of the diseased area and sometimes the wound heals over, but usually this callus becomes diseased. The following year healing is again attempted and the callus usually is again invaded. This process is repeated year after year so that several such calli are formed. The writer has seen as many as five on a single canker. In many of these cankers, by removing the bark, discolored areas can be seen extending into the healthy tissue at the upper and lower extremities. The cankers are always much longer than broad, but in many cases the branch is completely or almost girdled and the portion of the branch beyond the canker is killed.

In all of these cankers fruit spurs or branches are to be found, and to some of these were still clinging mummified peaches which had been attacked by the brown rot fungus, *Sclerotinia cinerea* (Bon.) Schroet. When this point was noted it suggested that these cankers might be caused by this fungus, it having gained entrance to the wood through the fruit spur and spread out in the bark when it reached the large limb, thus producing the canker. It seems to be the very general opinion among European workers that the brown rot fungus of America is *Sclerotinia cinerea*. The writer

has under observation cultures of *Sclerotinia cinerea* and *Sclerotinia fructigena* from Europe with which several of our American forms are being compared. At present he is of the opinion that our common form, usually called *Sclerotinia fructigena*, is really *Sclerotinia cinerea*, although further study is required to reach a satisfactory conclusion. In any case the organism mentioned in this paper is the common brown rot fungus of the peach and plum as it occurs in eastern United States. The discolored tissue in the cankers was examined and mycelium found in abundance. In one of the mounts made from a canker collected on May 4, 1911, conidial chains were found which were identical in every respect with those characteristically produced by the fungus, *Sclerotinia cinerea*, and on May 27 similar chains were found in another canker.

On June 7 poured plate cultures of potato agar were made from wood of cankers obtained from various places. The cankers were first sterilized by burning alcohol on the surface, then strips of diseased wood were cut out just under the bark with a sterile scalpel. These pieces were planted in poured plates of potato agar and within twenty-four hours ash-gray conidia were produced all over the wood. Microscopic examination showed them to be identical in size, shape and manner of growth with those produced by the fungus on peach mummies. Some of these conidia were transferred to slant tubes of potato agar and within a few days pure cultures of *Sclerotinia cinerea* were secured. During the summer of 1911 and 1912 similar results were repeatedly obtained.

On May 13, 1911 six brown rot peach mummies were tied to peach limbs and moistened several times daily in order to keep a film of moisture between the mummy and the bark. These were examined on May 26 and one had become fastened to the limb, to which it was tied, with a gummy substance. When the mummy was removed the limb showed the characteristic symptoms of brown rot canker, the fungus having apparently entered the limb through a slight injury in the bark. Pieces of bark were removed from three twigs with a sterile scalpel, and peach brown rot mummies were tied to the wood where the bark had been removed. When these were examined they were all found to be gumming heavily and showed distinct symptoms of the disease. Similar results were obtained repeatedly during the remainder of the summer. Plate X, figure 2, shows a canker produced in this manner. The mummy was tied to the peach limb in June, 1911, and the limb was collected and photographed in December, 1912.

On June 24 peach twigs were inoculated with conidia and pieces of mycelium from pure cultures of *Sclerotinia cinerea*. The most successful results were obtained when pieces of the mycelium were placed in contact with the cambium layer, then wrapping the wounds with paper. The checks were treated in exactly the same manner, except that no mycelium was placed in contact with the cambium layer. This method was employed in all of the

following inoculations. On June 23 five peach twigs were inoculated and five others were left as checks. When these were examined on June 28 infection had taken place in every wound which had been inoculated; and on some of them the characteristic ash-gray conidia of the fungus were being produced in large numbers, accompanied by oozing of gum about the wound, while in the checks there was only slight or no gumming and no evidence of infection. July 20, 21 and 22 ninety-five more limbs were treated in the same manner and inoculated, while ninety-five others were left as checks, thus making a total of one hundred inoculations and one hundred checks. These were all examined on August 5 and on all of the inoculated limbs typical brown rot cankers were being produced, accompanied by the oozing of a great abundance of gum from the wounds, while those twigs and branches which were merely cut and not inoculated were healing over, with little or no gumming. During the summer of 1912 similar inoculations were made using strains of the fungus obtained from various sources with the same results.

When the cankers produced by inoculation in 1911 were examined in the spring of 1912, and again in December, 1912, none of them showed any signs of healing over, while the checks had almost entirely healed. Plate X, figure 3, is a photograph of one of these inoculations as it appeared in December, 1912, and figure 4 is a photograph of a check as it appeared at the same time. Figure 5 is the photograph of a canker produced naturally. Four of these cankers produced by inoculation in 1911 were removed from the trees and brought into the laboratory, and on May 23 poured plate cultures were made from small pieces of wood taken just beneath the bark at the junction of diseased and healthy wood. When these were examined on June 1 mycelium had grown from these pieces of wood out on to the agar on the plates, and the typical ash-gray brown rot conidia were being produced. Transfers of these brown rot conidia were made to slant tubes of potato agar, and within a few days pure cultures of *Sclerotinia cinerea* were obtained. Thus, the fungus had remained alive in the cankers during the winter and only needed favorable conditions to call it forth into activity. Limbs of all sizes were used in these experiments, from the previous year's growth to the large main limbs of the tree, and infection took place readily in all cases. Some inoculations were made on current year's growth with the result that the fungus killed it outright, producing twig infection identical with that produced in nature.

A careful study of the peach orchards in the vicinity of Newfane revealed the fact that the fungus enters the limbs of the peach trees in two distinct ways, namely, through the diseased blossoms and through the diseased fruits. During the spring of 1911 and 1912 blossom infection was found to be very prevalent in the peach orchards around Olcott, Burt, and Newfane. It was especially abundant in orchards where brown rot apothecia were

produced in large numbers. Blossom infection was carefully studied during the spring of 1911 and 1912 and infection seemed to begin at the calyx or shuck and spread from there into the stamens and pistil, accompanied by a withering and browning of the diseased portion. Sometimes only the shuck becomes diseased and this is then shed without further injury to the pistil, but usually the entire flower becomes infected and the disease travels down the pedicel of the peach flower, finally entering the fruit spur, causing there the exudation of a large quantity of gum, which surrounds the blossom and seals it fast to the spur. Such diseased blossoms remain clinging to the fruit spurs during the entire summer, and whenever there is sufficient moisture the typical ash-gray conidia are produced in great abundance on the infected floral parts or fruit spur, and are a source of infection for healthy fruit. Where the fruit spurs are borne on large peach limbs the fungus may travel down the spur into the large limb where it spreads out and produces a canker. When the spur is produced on a small limb, that limb is killed outright and typical twig blight is produced. The fungus may continue this killing process until a large limb is finally reached and then may spread out and form a canker. Sometimes the fungus travels slowly, and only a small area surrounding the fruit spur becomes infected.

During the summers of 1911 and 1912 there was very little brown rot on the peach fruit in the Niagara district. What little did occur was found when the fruit was ripening. The brown rot on the fruit was carefully studied, and in almost every case it was observed that the disease passed into the fruit spur and from there gained entrance into the limb which bore the fruit. Sometimes cankers were eventually produced, while in other cases the disease progressed a short distance and apparently produced no further injury. On July 5, 1911, five peaches were inoculated with *Sclerotinia* spores by stabbing the fruit with a sterile needle, and introducing the spores. When these were examined on July 12, it was found that the fungus had entered the fruit spur in every case. Thus the fungus may enter the spur within seven days after the fruit becomes infected with brown rot.

The control of the canker disease may be undertaken along the three following lines: control of blossom infection, control of fruit infection, and by surgical methods.

For blossom infection self-boiled lime sulphur (8-8-50), concentrated lime-sulphur (1-40), and dusting with sulphur were tried. The applications were made just before the blossoms opened. Where the self-boiled lime-sulphur and dry sulphur were used, just as much blossom infection was found on the sprayed and dusted trees as on the untreated trees, but very little was found on the tree sprayed with concentrated lime-sulphur, and absolutely no injury to the blossoms or leaves resulted from the application.

Spraying for the control of brown rot on the fruit was attempted in several peach orchards during the summer of 1911 and 1912, using self-boiled lime-

sulphur (8-8-50), atomic sulphur (5-50), and sulphur in suspension (5-50), in all cases following the directions of W. M. Scott (7) in his bulletin on the Control of Peach Brown Rot and Scab. Very little brown rot occurred in the district during that time. Consequently, no results were obtained from most of these experiments. Where the disease was present, brown rot infection on the fruit was reduced from 10 per cent on the check trees to 1 per cent on the sprayed trees, all materials giving equally good results.

Many cankers in the vicinity of Burt and Newfane were cleaned and treated during the summer of 1911. In cleaning out the cankers all of the diseased wood was removed, the wound pointed at the upper and lower extremities, and the cambium and bark cut at right angles to the wood. The cankers were treated with a disinfectant (usually corrosive sublimate, 1-1000) and coated with gas tar. These treated cankers were frequently examined during the summer of 1912 and they were all observed to be healing nicely.

Except for the mention of this disease by Dr. Güssow (5) in his last report, the writer has never found brown rot reported as causing cankers on large peach limbs. It has been reported by Salmon (6) as producing a canker on apples in England. He asserts that the fungus enters the limbs directly from mummified fruits, and that conidia may be produced over the cankered area, breaking out through cracks in the bark from the underlying mycelium. F. A. Waugh (12) describes a canker on plum trees which he attributes to the brown rot and plum pocket fungi. His opinion is that the fungus starts the cankers by killing the fruit spur, which induces gumming, thus preventing the healing of the wound. The disease has been frequently reported as attacking the twigs of the peach, cherry, apple, and plum. Erwin F. Smith (8) records it as attacking peach twigs in the Delaware and Chesapeake peninsula. Card and Sprague (2) report that in 1901 and 1902 the diseases attacked the twigs of the sand cherry in Rhode Island.

Sorauer (9) is of the opinion that the fungus can attack the fruit and twigs more easily if they have first been wounded by frost or in other ways. Chester (3) notes it on peach twigs in Delaware in 1892, and Bailey (1) in New York in 1894. Taft (10) finds it on plum twigs in Michigan in 1894. Woronin (13) reports the brown rot fungi, of which he considers that there are two distinct species, *Sclerotinia cinerea* and *S. fructigena*, as attacking twigs of the cherry and apple in Russia. W. M. Scott (7) says: "The fungus also attacks the twigs, thus often destroying a portion of the fruit crops at blossoming time. The diseased blossoms turn brown and become dried, adhering to the twigs for some weeks. The fungus may extend from the dead blossoms into the bark, forming a small brown canker which frequently girdles the twig." Goff (4) reports the disease as attacking the native plums in Wisconsin, and E. Voges states that *Sclerotinia fructigena*

and *Sclerotinia cinerea* attack apple and cherry twigs in Germany. Dr. Shear, at the Cleveland meeting of the American Phytopathological Society, reports it as exceedingly destructive, and as producing large cankers on cherries, plums, and apples in Europe.

The writer wishes to acknowledge his indebtedness to Dr. D. Reddick for numerous helpful criticisms and suggestions.

KANSAS AGRICULTURAL COLLEGE

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EXPLANATION OF PLATE X

FIG. 1. A peach orchard near Burt, N. Y. severely infested with brown rot canker. There were from twenty-five to fifty cankers on almost every tree.

FIG. 2. A brown rot canker produced on a peach limb by removing a piece of bark with a sterile scalpel and tying a peach mummy to the exposed portion.

FIG. 3. A brown rot canker produced on a peach limb by removing a piece of bark with a sterile scalpel and introducing spores and mycelium from pure cultures of *Sclerotinia cinerea* just beneath the cambium.

FIG. 4. A peach limb treated in exactly the same manner, except that no spores or mycelium were introduced into the wound. Note that the wound has almost completely healed over.

FIG. 5. A peach limb upon which a brown rot canker has been naturally produced. Note the fruit spur through which the fungus entered the limb from a diseased fruit.



PLATE X BROWN ROT CANKER OF PEACH

NOTES ON SOME DISEASES OF TREES IN OUR NATIONAL FORESTS. III¹

GEORGE GRANT HEDGECOCK

The present paper is a continuation of observational notes² on forest diseases, made chiefly by the writer during August, September and October, 1912.

WOOD-ROTTING DISEASES OF FOREST TREES

Polyporus dryophilus Berk., or a closely related species, is the cause of a disease of the heartwood of the aspen (*Populus tremuloides*) in some portions of Colorado. Like *Fomes applanatus* (Pers.) Wallr, it is associated with *Fomes igniarius* (L.) Gillet. It attacks the trunk of the trees chiefly, entering the heartwood either through fire scars or in the base of dead limbs after they are broken off, and causes a heart rot of a yellowish color, interspersed with strands of brown mycelia near the region where the sporophores originate. The trees die either by breaking off, or in some cases, from the direct effect of the fungus, which, when the disease becomes far advanced, attacks the sapwood, producing a white rot. This in the aspen is not a piped rot, such as is caused by *P. dryophilus* in species of oaks. The difference in the texture of the rotten wood in the aspen as compared with that in the oaks can hardly be ascribed to a difference in the wood of the hosts attacked, and since the sporophores vary slightly from those of *P. dryophilus* in form and color, it is very probable that the fungus is a different species.

Armillaria mellea Vahl attacks the roots of many species of trees both in our eastern and western forests. It, or a closely related species, is known to attack the following host trees: *Alnus oregona*, *Betula lutea*, *B. nigra*, *Castanea dentata*, *Larix occidentalis*, *Pinus contorta*, *P. flexilis*, *P. ponderosa*, *Platanus wrightii*, *Populus tremuloides*, *Robinia pseudacacia*, *Tsuga heterophylla* and various species of *Quercus*.

WINTER AND FROST INJURIES TO FOREST TREES

It is not uncommon in mountain valleys, especially in Colorado and to the northward, to note in late spring a killing of the young growing tips of coniferous trees. This takes place during a severe frost or freeze occurring

¹ Published by permission of the Secretary of Agriculture.

² Hedgecock, George G. Notes on some diseases of trees in our national forests. II. Phytopathology 2: 73-80. April, 1912.

after the young ends of the shoots have formed a new growth of leaves. The young leaves and stems being still soft and succulent are apparently killed by the rupture of cells in their tissues. They wilt down and die at once, assuming a reddish tinge or color, and remain in a recurved position. This recurved position and reddened color is common to a number of species of conifers which suffer injury, especially *Abies lasiocarpa*, *A. concolor*, *Picea engelmannii*, *P. parryana*, *Pseudotsuga taxifolia* and *Larix occidentalis*. The injury usually occurs either in narrow valleys and canyons or near where these open into larger valleys or canyons. Such localities are often known as "frost pockets," owing to the frequent recurrence of late frosts in such places. The frequent injury to the trees may give them a ragged appearance, due to an uneven growth of the twigs and limbs.

A second form of injury, a true winter injury, which in some localities has been called the "red belt," occurs in a mild form sporadically in small areas every year in some one of the northern Rocky Mountain states. The last general occurrence in a severe form was during the winter of 1908-1909³ when 40,000 acres of trees were killed and many more injured in Montana alone. The injury also occurred in isolated localities as far east as the Black Hills in South Dakota, and as far south as Colorado.⁴

In this form of injury, which usually occurs either in mid-winter or in early spring, the leaves of conifers redden and dry up, the younger leaves being the most often affected. The growing tip is often killed and even the cambium layer on one side of the tree may be injured, the injury being usually more severe on the west side of the trees affected. It is more common on westerly and north westerly slopes and in narrow belts at certain altitudes, but, in one instance noted, trees on a southerly slope were also injured. During the winter of 1910-1911 such an injury occurred to trees on a series of southerly slopes near Monarch, Montana. Conifers on these slopes exhibited marked indication of injury the following summer, but during the next season they partially recovered, although often presenting a ragged appearance on the northwest side, due to the premature shedding of the leaves and to the death of many of the terminal buds. Trees of the following species, named in order of the injury received, from the greatest to the least, were injured near Monarch: *Pinus contorta*, *Pinus ponderosa*, *Pseudotsuga taxifolia*, *Abies lasiocarpa*, *Pinus flexilis*, *Juniperus scopulorum*, *Juniperus occidentalis* and *Juniperus sibirica*. The last three species suffered only a slight injury to some of the leaves on the upper shoots. Very little or no snow was on the ground at the time the injury took place.

³ Hedgcock, George G. Winter-killing and smelter-injury in the forests of Montana. *Torreya* 12: 25-30. 1912

⁴ Hartley, Carl P. Notes on winter-killing of forest trees. *Forest Club Annual* (University of Nebraska) 4: 39-50. 1912.

During the present summer (1912) a small belt of injury of this kind, which had taken place during the winter of 1911-1912, was noted on young lodgepole pines (*Pinus contorta*) near Rollinsville, Colorado, on a westerly slope a few miles east of the continental divide.

Owing to the fact that, in all cases noted, the trees were injured worst on the west side, and the death of the leaves and shoots was apparently a drying-out process, it is believed by many observers that the injury is caused by warm, dry, westerly winds of high velocity which are in the nature of "chinook" winds.⁵ These affect only those trees which have their roots immersed in frozen earth. At the higher elevations the early snows cover the earth with a deep blanket, and it is assumed that, as a rule, the roots of the trees in our mountain forests are not encased in frozen earth in mid-winter. A warm spell and thaw often removes all the snow on more exposed slopes at lower elevations, and there is a temporary raising of the snow line to a higher elevation. Severe cold weather without snow freezes the bare ground on these exposed positions, and the trees found here are subject to winter injury, provided that proper air conditions and high, warm, dry, winds occur while their roots are in this condition, even though the frozen earth may afterward be covered with snow. Again, a portion of the forests lower down may be subjected a second time to a thawing-out process, leaving the soil free of frost, only to be followed by a heavy snow, so that both higher up and lower down the earth is not frozen, while midway there is a belt of frozen earth beneath the snow. This latter view, which I believe was first advanced by D. T. Mason, Assistant District Forester, is favored by a number of western investigators.

SMELTER INJURY TO THE FORESTS

A visit was made by the writer in October, 1912, to the region near the great Washoe smelter at Anaconda, Montana. The belt of acute smelter injury in the Deerlodge national forest in the vicinity of Anaconda has been greatly extended during 1911 and 1912, especially during the past growing season. Acute injury to the lodgepole pines has become general in a number of localities from nine to twelve miles from the smelter, where formerly the trees exhibited only the chronic form. The trees in these localities are dying rapidly.

Limber pines (*Pinus flexilis*) on the south slope of the hills adjacent to the smelter on the southwest exhibit the acute form of smelter injury this season and are dying slowly. A study of the cells of the leaves of this species of pine and of the two species of Juniper also present, reveal the fact that these species, which have been considered resistant to smoke,

⁵ Hartley, Carl P. Loc. cit., p. 46.

do suffer injury from the fumes, even where the leaves are not apparently injured. The accretion rings of the wood of *Pinus flexilis*, even at a distance of ten miles from the smelter, show a gradual diminution of growth in recent years, and it is a grave question whether it would be possible to reforest with this species in the smelter zone by the process of artificial planting. Within the region of acute injury no fertile seeds were found in the cones of any species of conifers, with the exception of the junipers. This proves that there is no hope of natural reforestation in this region under the existing conditions.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY

BUREAU OF PLANT INDUSTRY

WASHINGTON, D. C.

ABNORMAL ROOTS OF FIGS

FREDERICK A. WOLF

WITH PLATE XI

Several small branches taken from cultivated fig trees, which for a number of years have either failed entirely to set fruit or have produced only a small crop, were recently sent me for examination as to the cause of this condition. Upon these twigs were numerous cylindrical or conical outgrowths 3 to 5 mm. in length and 1 to 2 mm. in diameter at the base. It was found upon visiting the orchard subsequently that these processes were present also upon the trunk and larger branches, occurring for the most part upon the lower side of the limbs or on the north side of the trees. These outgrowths may be more or less grouped or isolated as shown in figure 2, and in the young condition show a fissure in the cortex, indicating that they have been formed from the underlying tissues and have penetrated the bark upon emergence.

Outgrowths similar in appearance, and apparently similar in structure, have been observed from time to time both on herbaceous and woody plants, but so far as is known no previous account has been made of their occurrence on cultivated figs. Kissa (1) described them as "Kropfmaser" on *Pirus malus chinensis*, Jaeger (2) on apples, Sorauer (3) on *Ribes nigrum*, *Prunus padus*, *Cydonia vulgaris*, and on species of *Acer* and *Tilia*. Among the writings of Meyen, Göppert, Schlacht, Trécul, Dutrochet, Hartig, Masters and Frank one may find descriptions of these pathological formations. The so called "chichi" of *Gingko biloba* (4) is of the same nature. The cylindrical processes of *Gingko*, the smaller of which are the size of one's finger and the larger 2.2 meters in length and 30 cm. in diameter, resemble twigs, except that no leaves are developed unless they come in contact with the soil, in which case roots may also be formed. In cross section they reveal annual rings, continuous with those of the branch. The outgrowths on figs, however, reveal no evidence of a yearly increment of growth.

Several cuttings of these diseased figs were placed in moist soil under bell jars to permit the further development of the processes. All of the outgrowths which were buried in the soil continued to grow as is shown in figure 1, so that within ten days many of them were an inch or more in length. Those above the surface of the soil exhibited no developmental changes,

but in the course of time new outgrowths, similar to those already present, were formed. An examination of the anatomy of these cylindrical growths from transverse and longitudinal sections adds further evidence to the fact that they are roots which have arisen from dormant buds. They are found to possess radial vascular bundles with a tetrarch arrangement of the elements.

Various explanations have from time to time been given to account for hyperplastic development of this sort in plant tissues. Frank (5) regards the large projections as due to adventitious buds and the smaller ones to an abnormal increase in size and form of the medullary rays. In the case of *Ginkgo* (4) the formation of "masercylinder" could always be traced back to a latent bud, and provisional buds developed from it. In certain other plants the processes have been described as outgrowths of cortical tissue. Sorauer (3, p. 385) found that gooseberries which grew near a compost heap formed these projections, indicating that there was a local plasmatic derangement in certain tissues, the over supply of food having tended to produce a change in turgor. Kenjiro Fujii (4) suggests that the formation of "masercylinder" of *Ginkgo* is accompanied by an indication of local increase of nourishment. Frost injury has been regarded as an inciting cause. Mites and lice may exercise an influence in initiating the development of outgrowths. However, the development by figs of processes which are morphologically roots and which may be made to function as roots if they are brought in contact with the soil, seems to be primarily a response to a superabundance of moisture. The annual rainfall for the locality in which the trees are growing is between 60 and 70 inches. Further than this the affected trees are so shaded and protected against suitable air drainage by buildings and other trees that the growth of vegetation on the ground floor is completely inhibited. The absence of direct illumination seems, however, to be only an indirect factor, judged from experiments in which new outgrowths were formed by plants placed under bell jars and exposed to direct sunlight.

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EXPLANATION OF PLATE XI

FIG. 1. A twig which was placed in wet soil to the bud at *a*.

FIG. 2. The projections have grown into true roots. Twigs taken from trees which show the numerous processes. Almost natural size.



PLATE XI

ABNORMAL ROOTS OF FIGS

THE JONATHAN SPOT ROT¹

MEL. T. COOK AND G. W. MARTIN

One of the most troublesome storage rot of apples in New Jersey is the so-called "Jonathan spot." The spots appear soon after the fruit comes from cold storage and may also occur on mature fruit in the orchard, especially when it is picked late. They are small, seldom more than 1 cm. in diameter, usually circular, brownish or black in color and slightly sunken. In most cases the point of infection appears to be through the lenticels, but infections may occur through fruit cracks and other slight wounds. The diseased tissue is dry, shallow and may be readily separated from the healthy tissue. It can be easily distinguished from the Baldwin spot and from the New Hampshire fruit spot. The writers have also found what appears to be the same disease on Nero, Smokehouse and Newtown Pippin.²

Cultures were made from these spots by means of the following method. The surface of the fruit was thoroughly disinfected with a 5 per cent formalin solution and then washed with sterilized water. The peel from the large spots was removed with a sterile knife and small bits of the tissue were put in petri dishes containing culture media. In the case of the extremely small spots the cut surface of the bit of peel was placed directly against the medium. Fully 90 per cent of these cultures, including those made from the smallest spots that we were able to detect, gave luxuriant and characteristic growths of *Alternaria*.

Repeated inoculation experiments indicate that the organism which we isolated from the Jonathan spot can cause typical spot rot. However, our inability to secure Jonathan apples which were absolutely free from the disease made these experiments unsatisfactory. Our checks almost invariably developed the spots and therefore our only method of determining the effect of the inoculations was by counting the spots, which necessarily made the results inconclusive.

An *Alternaria* rot was first reported as attacking both apples and pears by Longyear of Colorado, in 1905, who also reported finding an *Alternaria*

¹ Read before the American Phytopathological Society at Cleveland, O., January 2, 1913.

² Since the presentation of this paper, Scott and Roberts have reported a "Jonathan spot," which they consider a physiological trouble, on Jonathan, Esopus, Yellow Newton, Grimes Golden and Arkansas Black. U. S. Dept. Agr., Bur. Pl. Ind. Circ. 112. February 8, 1913.

in the cores of apples from California. This disease, however, was strictly a blossom-end and core rot and is not mentioned as being the cause of a spot rot. We also have collected *Alternaria* blossom-end and core rots from Gravensteins and White Ohio Pippins in New Jersey, but the organisms would not cause the Jonathan spot, nor did they seem to be quite the same as the *Alternaria* isolated from the typical Jonathan spots. Furthermore, cultures from core rots in western Winesaps gave two *Alternarias*, one with long and the other with short spores, but both failed to produce Jonathan spot rot, although the former would readily produce a soft rot. This appears to indicate that the Colorado blossom-end and core rot is different from the New Jersey Jonathan spot rot but may be the same as the New Jersey blossom-end and core rot. Storage rot due to *Alternaria* has also been reported by H. J. Eustace, but there is no way of determining which particular form is responsible. Morse and Lewis reported an *Alternaria* from Maine in 1910 as causing a blossom-end rot and also as attacking the fruit through wounds, but they did not connect this organism with the forms occurring on the twigs and foliage.

It appears to the writers that we have at least three different species or varieties of *Alternaria* causing apple rots: (1) one causing a blossom-end and core rot, which is probably very widely distributed throughout the country; (2) one causing a dry spot rot on the Jonathan, and probably on other varieties, and distributed over a more restricted area; (3) one or more either causing or following storage rots.

This disease is becoming more and more severe in New Jersey and it is very evident that our orchard treatments must take it into consideration. The data secured up to the present time indicate that the infection occurs in the orchard and that the susceptibility of the various varieties depends on the character of the lenticels. The time of infection and the method of treatment are still undetermined but work will be carried on throughout the coming year.

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STUDIES ON THE WATER CORE OF APPLE

P. J. O'GARA

WITH TWO FIGURES IN THE TEXT

Water core of apple is a trouble which is not restricted to any one district where apples are grown, but is found to occur more or less generally over the country, particularly in the arid and semi-arid districts. Reports of this trouble have also come from apple growing districts of Europe, Asia and Africa. Although the trouble has been known for some time, data of very little importance is to be found in American plant pathological and physiological literature. It seems that very little serious work has been done in the matter of determining the true cause of the disease. Some European writers have held that the disease is caused by bacteria, although others have shown that the trouble is not due to any parasitic agency.

The writer has done considerable work on this disease during the past few years, and in no case has it been possible to identify any organism as the causative agent. All the methods known to modern bacteriology especially those used in the study of ultra-microscopic organisms, have failed to show the presence of any organism. Numerous attempts have been made to inoculate healthy fruits by injecting the juice from water-cored spots of diseased apples, but in no case did the inoculated fruits develop any symptoms of water core. In a previous paper¹ the writer mentions the presence of various organisms, especially *Alternaria* sp., in connection with his studies on water core, but in no case could it be shown that any organism caused the disease.

The characteristic appearance of water-cored apples is so well known that a minute description is hardly necessary here. The affected apples have hard watery areas extending outward from the outer edges of the seed cavities. In the beginning stages, the first appearance of water core is in connection with the vascular system. Each bundle will show a water-soaked area surrounding it, and, as a rule, this area makes its appearance a short distance from the stem. As the vascular system is variously branched upward, water-soaked areas may appear at almost any place in the fruit. In later stages the seed cavity usually contains liquid, and the hard inner membrane of the carpels is cracked and covered with hair-like growths

¹ O'Gara, P. J. Water Core of Apple. Office of the Pathologist and Entomologist for Rogue River Valley, Medford, Oregon. Bulletin 9. October 11, 1912.

which finally assume a brownish appearance. The fruit has a somewhat sweetish, fermented flavor, and the watery parts contain more sugar and less acid than the normal or unaffected parts. It is during the later stages of the disease, especially where cracks appear in the calyx- or blossom-end, that we find fungi and bacteria present. *Alternaria* sp. is a common intruder, and produces a serious core rot. This latter trouble, namely, *Alternaria* infection, may be prevented by the proper and timely application of Bordeaux mixture.

During the past season the writer has had the good fortune to be able to do some very interesting work in connection with water core. It was found that conditions affecting transpiration are the prime factors inducing this disease. (I use the term "disease" because I believe that it is just as correct in this case as though the trouble were due to a parasitic organism.) The conditions affecting transpiration in plants are so well known to plant physiologists that I need not enumerate them here. Before giving the data upon which my conclusions are based, I shall enumerate the conditions favoring water core. It must be understood that no single condition may produce water core; as a rule, it is a combination of perhaps two or more factors. In some cases avoidance of the trouble may be possible; however, for the most part, it is entirely impossible to prevent it because of the fact that certain climatological factors enter into the problem. The most prominent factors inducing water core are:

1. Excessive or strong vegetative growth, especially in young trees just coming into bearing. Such trees usually set light crops and the fruits are abnormal in size. Fruits borne far out on the terminals are very liable to water core, whether the trees are old or young, providing the trees are vigorous. Trees making poor growth, which may be caused by soil conditions, lack of moisture, root trouble, or any other cause, rarely show water core in the fruit.

2. High cultivation is a factor, but alone would not cause the trouble. However, well cultivated soils retain moisture much better than those which are not cultivated, hence, as a rule, high cultivation will promote vigorous growth and, therefore, favors water core, providing other factors are present.

3. Excessive precipitation or irrigation shortly before the maturity of the fruit, if followed by great extremes of temperature and atmospheric humidity, are factors of the greatest importance. During hours of sunshine the moist ground is warmed to such an extent that water is readily taken up by the root system, and at this time transpiration is also very rapid. During the night the atmospheric temperature lowers to the point of saturation, this often being very little above the freezing point; however, the moist soil in which the roots are growing remains warm, or at least several degrees

above that of the air temperature. Under such conditions, sap pressure is continuous, but transpiration is checked. Evaporation cannot take place from any surface when the surrounding medium (air, in this case) has reached the point of saturation. With transpiration checked and the sap pressure continuing, the tissues along the lines of greatest pressure must give way. These tissues are found in the fruits, especially those farthest out on the terminals, because they are exposed to extremes of temperature. Fruits on the south or southwest sides of trees are always most affected.

4. Severe pruning shortly before the ripening period, or defoliation by disease or otherwise, thus causing the fruit to be exposed as well as reducing the evaporation surface of the tree, will have a tendency to produce water core.

5. Frosts, which are severe enough to injure the foliage, have an effect similar to that of defoliation, since leaves which are so injured no longer function as true agents of transpiration. Certain chemical activities are also set up in plants after frosts have injured them, and this produces rapid ripening in the case of apples. It is quite noticeable after a heavy frost that apples color rapidly, this being due to the formation and activity of certain enzymes.

6. Cell tension or turgor may be induced by the rapid conversion of starch into sugar. This tension may be caused in two ways: (1) by the rapid absorption of water by the sugar through osmotic pressure; (2) by the rearrangement of the molecules during the process of starch conversion into sugar. This, however, is of less importance than the other factors enumerated above.

The weather conditions which favored water core during this season, particularly in this district, are shown in the accompanying tables of temperature, relative humidity and precipitation for the period beginning August 26 and ending September 30, 1912. The thermograph records showing the peculiarity of the temperature curves are also given. For convenience in showing the relationship between temperature and humidity, the extremes of relative humidity in percentages are shown graphically on the thermograph records. This is done because there was no hygrograph at hand to trace the actual relative humidity curves. The months of July and August were particularly dry, the precipitation for July being 0.20 inches, and for August 0.07 inches. During this period practically clear weather prevailed. Beginning with August 31 and ending September 8, 1.15 inches of rain fell. Following this period of moderate temperatures came three weeks of clear weather with high temperatures during the hours of sunshine and low temperatures during the nights. As will be seen by inspecting the table and the thermograph records for this period, the daily range of temperature reached as high as 48°F. The difference in relative

TABLE I

Maximum and minimum temperatures, relative humidity, precipitation and state of weather. United States Weather Bureau Station, Medford, Oregon, August 26 to September 30, 1912

DATE	TEMPERATURE			RELATIVE HUMIDITY			PRECIPITATION	STATE OF WEATHER
	Max.	Min.	Range	5.00 a.m.	5.00 p.m.	Range		
	°F.	°F.	°F.	percent	percent	percent	inch	
August								
26	80	54	26	83	29	54	0	Cloudy
27	72	56	16	82	44	38	0	Cloudy
28	71	55	16	82	39	43	0	Clear
29	71	39	32	87	23	64	0	Cloudy
30	77	40	37	89	38	51	0	Cloudy
31	69	51	18	88	53	35	0.04	Cloudy
September								
1	74	47	27	87	37	50	0	Partly cloudy
2	60	46	14	55	54	1	0.04	Cloudy
3	60	46	14	87	57	30	0.06	Cloudy
4	68	48	20	93	39	54	0.03	Partly cloudy
5	64	49	15	93	58	35	0.10	Cloudy
6	56	47	9	93	65	28	0.70	Cloudy
7	64	46	18	86	73	13	0.01	Cloudy
8	68	47	21	93	47	46	0.14	Partly cloudy
9	76	40	36	69	34	35	0	Clear
10	84	43	41	86	23	63	0	Clear
11	84	43	41	78	31	47	0	Clear
12	86	44	42	79	26	53	0	Clear
13	90	47	43	79	23	56	0	Clear
14	90	49	41	81	24	57	0	Clear
15	88	54	34	82	20	62	0	Clear
16	77	47	30	87	51	36	0	Clear
17	74	55	19	82	40	42	0	Partly cloudy
18	86	45	41	79	34	45	0	Clear
19	86	47	39	81	29	52	0	Clear
20	90	46	44	73	17	56	0	Clear
21	89	44	45	79	18	61	0	Clear
22	84	45	39	80	27	53	0	Clear
23	77	40	37	85	39	46	0	Clear
24	76	36	40	92	28	64	0	Clear
25	84	36	48	92	20	72	0	Clear
26	87	39	48	92	17	75	0	Clear
27	75	48	27	67	59	8	trace	Cloudy
28	76	51	25	88	54	34	trace	Partly cloudy
29	80	48	32	87	32	55	0	Clear
30	70	45	25	93	63	30	0.03	Partly cloudy

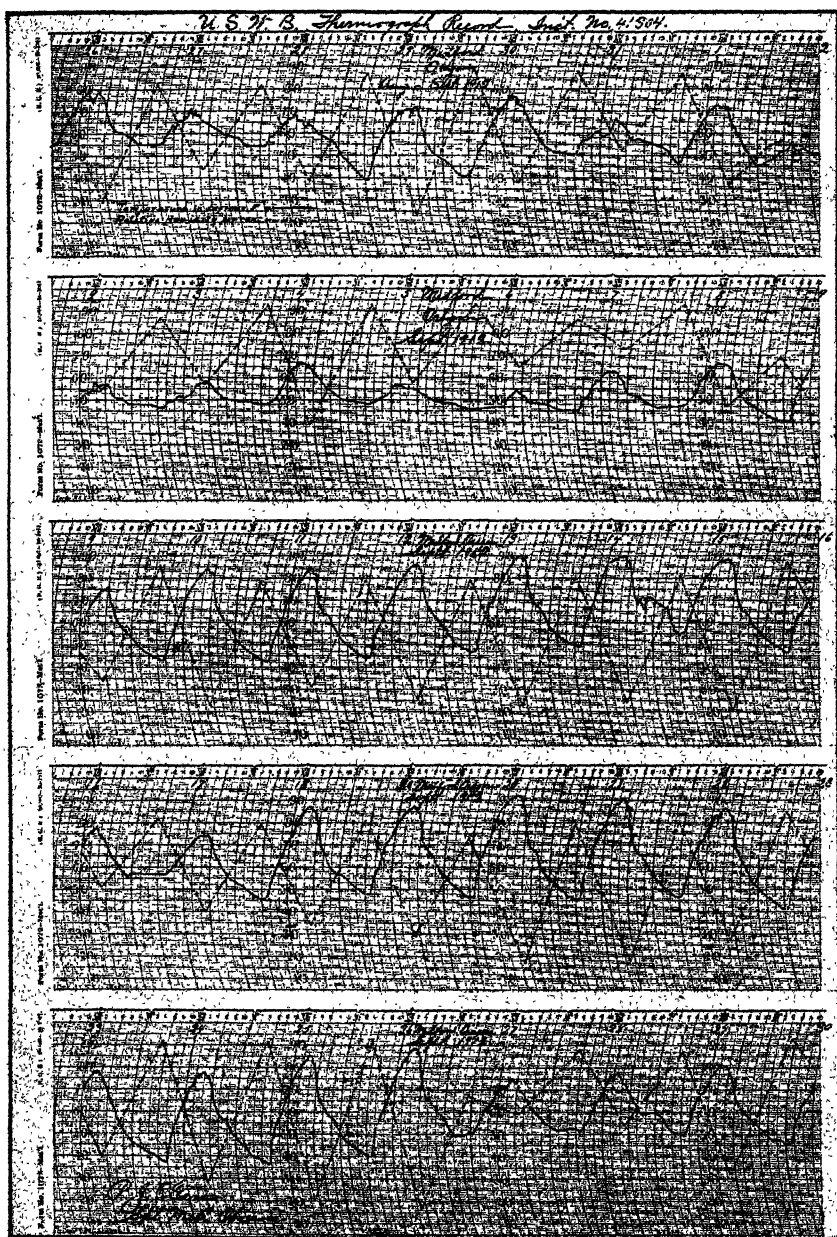


FIG. 1. THERMOGRAPH RECORDS WITH RANGE OF RELATIVE HUMIDITY, MEDFORD, OREGON, AUGUST 26, TO SEPTEMBER 30, 1912

The full lines show temperature degrees Fahrenheit. The dotted lines indicate percentage relative humidity, and simply mark the extremes.

humidity during a twelve-hour period reached as high as 75 per cent. The table given is taken from the records of the United States Weather Bureau, Medford, Oregon, the readings having been made at approximately 5.00 A.M. and 5.00 P.M. local time (Pacific time). The 5.00 A.M. readings of relative humidity correspond very closely with the time of minimum temperatures while the 5.00 P.M. readings correspond fairly well with the time of maximum temperatures. Had the relative humidity readings been taken at the exact time of maximum and minimum temperatures greater extremes of relative humidity would have been observed.

A careful examination of orchards of the same age and variety showed that the amount of water core present in the fruit was in direct proportion to the amount of precipitation or irrigation, range in temperature and range in relative humidity. The records given in the tables are those taken on the valley floor where the range in both temperature and relative humidity was very great. At elevations where this range was not so great, there was very little water core. The amount of precipitation also had its effect. In orchards where the precipitation was light, water core was much less abundant. A very interesting case was noted where the rainfall was supplemented by a heavy irrigation, both preceding and after the rain occurred. In this orchard over 90 per cent of the fruit showed water core, while an adjacent orchard on the same type of soil, with the same varieties of apples, but not irrigated, showed not over 5 per cent of the fruit affected. Another interesting case was noted where an orchard was severely pruned during the latter part of August, exposing most of the fruit. In this orchard, nearly all of the fruit became water-cored, while an adjacent orchard growing under the same conditions, but unpruned, had very little water core. Another orchard where one half the trees were pruned, as above, showed 90 per cent water core in the part pruned, while the unpruned trees did not show more than 5 per cent.

As has been stated before, water core is more liable to occur in exposed fruits, especially those far out on the terminals and those on the south or southwest parts of the tree. In order to prove that this is universally true, I had a large number of boxes of fruit picked from the south and southwest parts of trees by pickers who did not know my purpose. I also had fruit picked from the unexposed parts of trees. In the former case, fully 90 per cent of the fruit showed water core, while less than 5 per cent were found to be water-cored in the latter case. This proved to be a very important matter in the segregation of water-cored fruits preparatory to boxing for shipment.

The examination of water-cored fruit shows that it is water-cored in proportion to its exposure to extremes of temperature and humidity. The side or part of an apple presented to the direct action of the sun's rays will

show more water-soaked tissue than the part not so exposed. In the orchard, or even with the fruit in the boxes, the careful observer may pick out the water-cored fruit, although no evidence of water-soaked tissue may be seen. Usually, water-cored apples have a much higher color than those not affected. In the Newtown, a yellow variety, a blush or colored cheek



FIG. 2. LONGITUDINAL AND CROSS SECTION OF NEWTOWN APPLE AFFECTED WITH WATER CORE

In both sections of the fruit the parts marked *v* are vascular bundles, which are ten in number. It will be noted in the cross section that the upper bundles show smaller areas of water soaked tissue than the lower bundles which have rather large areas surrounding them showing a water soaked appearance. In the region marked *c* of the cross section there are large areas of water cored tissue, the injury extending outward to the epidermis. This water soaked area is on the side of the fruit presented to the direct rays of the sun, while the upper side, showing practically no water core, is on the side away from the sun. The cracked carpel with its hairy growths is shown at *w*. It is best seen in the longitudinal section, which also shows very plainly the connection of the vascular strands marked *v* with the stem. This fruit was taken from a terminal on the southwest side of a vigorous ten-year-old Newtown tree, and did not outwardly show water core.

usually indicates a water-cored fruit. A normal Newtown should be green when picked. Water core is much more easily detected in yellow than in red varieties of apples.

Under proper storage conditions, water-cored fruit, unless badly affected, will entirely recover. This will be the case where no liquid fills the seed cavities and if the fruit is placed in a cool, even-temperated place (not

cold storage). The fact that water-cored fruit will become normal, the water soaked spots entirely disappearing under proper storage conditions, demonstrates the non-parasitic nature of the trouble. As soon as it is found that apples are becoming water-cored, they should be immediately picked and placed in proper storage. If allowed to remain on the trees until liquid fills the seed cavities, ultimate recovery is almost impossible. Besides, various organisms gain access to the fruit and complete its destruction.

In an experiment, 1000 boxes of Newtown apples showing fully 90 per cent water core were stored for about three weeks. The percentage of water core was carefully determined before putting the fruit into storage. As far as possible all fruits very badly water-cored and evidently having the seed cavities filled with liquid were not put into storage. At the end of three weeks the fruit was again examined and showed scarcely 1 per cent water core. The only cases not fully recovering were those in which the seed cavities had become filled with liquid, and in which fermentative processes had been set up.

MEDFORD, OREGON

NOTES ON DISEASES OF TREES IN THE SOUTHERN APPALACHIANS I

ARTHUR H. GRAVES

WITH TEN FIGURES IN THE TEXT

In the summer of 1910 the writer was detailed by the United States Forest Service to make a general survey of the diseases of trees in the southern Appalachian mountains. The work was done in collaboration with the Office of Investigations in Forest Pathology, Bureau of Plant Industry. At the request of the Forest Service, special attention was given to the diseases of four timber trees: i.e., *Pinus virginiana* Mill., *Quercus rubra* L., *Castanea dentata* (Marsh.) Borkh., and *Liriodendron Tulipifera* L. A small part of the results of this work has already been incorporated in a bulletin by W. D. Sterrett.¹

In addition to the work on these four species, notes and collections were made of all fungi which were found to be associated with disease in other tree species. Saprophytic fungi attacking wood were also collected, and a list of these will be given later. One set of these specimens has been added to the herbarium of the Office of Investigations in Forest Pathology, Bureau of Plant Industry, and a duplicate set, sent to Yale University, is preserved in the Eaton Herbarium of that institution.

In the study of this material during the past two years, several hitherto undescribed or little known diseases have been found. An account of one of these² has already been published. It is the purpose of the writer in the following notes, the first of a series of papers, to bring together the most important data obtained in this work in the field and from subsequent study in the laboratory, including also distributional notes on the better known diseases; in order that they may be of assistance in furthering our knowledge of the diseases of trees in this region.

The diseases will be treated according to host species, the arrangement of hosts following that of Sudworth's Check List of the Forest Trees of the United States.³

¹ Sterrett, W. D. Scrub pine (*Pinus virginiana*). U. S. Dept. Agr., Forest Service Bul. 94: 1-27, figs. 1-2. July, 1911.

² Graves, Arthur H. The large leaf spot of chestnut and oak. *Mycologia* 4: 170-174. 1912.

³ Sudworth, George B. Check list of the forest trees of the United States. U. S. Dept. Agr., Forest Service Bul. 17: 1-144. 1898.

SOME DISEASES OF THE WHITE PINE (*Pinus strobus* L.)BARK BLIGHT. *Coccomyces Pini* (Alb. & Schw.) Karst.

This was observed on two living white pines near Tallulah Falls, Georgia. The trees were about 1 foot in diameter, breast high, and apparently healthy as regards the leaves and the main trunk. Many of the branches, however, which indeed still had healthy leaves, showed a reddish stripe in the bark, extending for a considerable distance longitudinally,

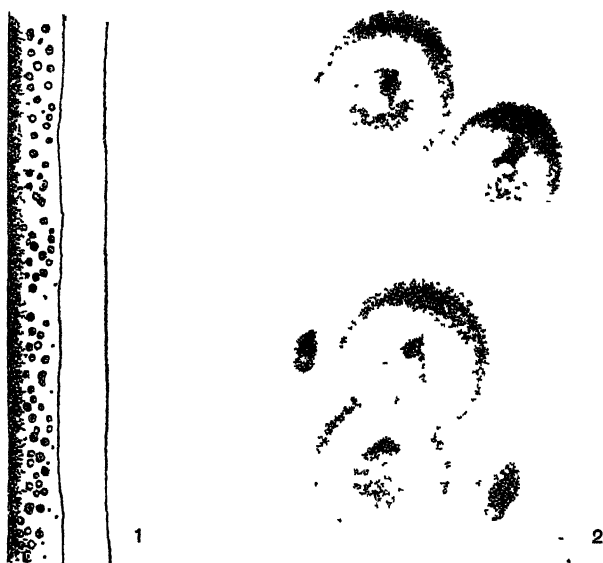


FIG. 1. Part of diseased branch; showing lesion (stippled portion) and fruiting bodies. $\times 2$.

FIG. 2. Fruiting bodies of *Coccomyces Pini* (Alb. & Schw.) Karst. $\times 45$.

and occasionally taking up as much as an inch of the branch circumference, though usually somewhat less than this. These stripes showed a fairly even demarcation from the healthy bark (fig. 1), so that the contrast between the red-brown of the diseased portion, and the brownish-green of the healthy part was strongly marked. It should be noted also that in many cases the terminal portions of the branches thus attacked were entirely diseased and dead.

On the diseased portions fruiting bodies of a fungus were clearly apparent to the naked eye. These varied considerably in size and shape between

two extremes: i.e., from the larger type, which is a low disc-like protuberance, often 1 mm. in diameter, with a central concavity in the middle of which the papillate opening into the interior appears—passing through smaller sizes of this same structure, where no concavity appears—to the form in which simply a black pustule, raised a slight distance above the bark, indicates the opening into the interior of the fruiting body (fig. 2). All intergradations between these two extreme types were found, so that it seemed unreasonable on account of the form alone to regard them as two forms of fruiting bodies. Cross sections revealed large numbers of filiform, hyaline, one-celled spores, usually straight, but sometimes slightly curved (fig. 3). These were found in all the forms of fruiting bodies, so that the latter may properly be regarded as pycnidia. However, it should be stated that the asceigerous form, or apothecium, in the exsiccati examined by the writer, corresponds in external appearance to the larger form of pycnidium.

The fungus is the imperfect form of *Coccomyces Pini* (Alb. & Schw.) Karst., a member of the Phacidiaeeae, a plant which has several synonyms, chief of which are *Coccophacidium Pini* Rehm⁴ and *Phaculium Pini* Fr.⁵ Exsiccati distributed under the latter name by Rabenhorst (Fungi Eur. 3568. 1886) and De Thuemen (Myc. Univ. 179. 1875) have been examined and correspond with the species in question. Saccardo's⁶ description assigns a diameter of 1.5 to 4 mm. to the fruiting bodies, but since these figures refer to mature apothecia, such a disparity might be expected. The pycnosporos in our specimens average $7.5 \times 0.6\mu$, figures which are not greatly at variance with those given by Saccardo— $10 \times 1\mu$ (fig. 3). As is characteristic of the fruiting body of the Phacidiales, at maturity a cracking open of the covering in a more or less star-shaped form occurs (fig. 4).

Judging from the manner in which this fungus appears on the living branches, the writer is inclined to the belief that it is a facultative parasite, for, as already intimated, besides its frequent occurrence in the long discolored strips surrounded by the healthy bark, it often entirely envelops the smaller, terminal twigs, which are quite dead, apparently as a result of its attack. On the other hand, it is quite possible that its attack is of a secondary nature: i.e., preceded by injury to the branches from drought, cold, sun-scald, etc. A point in favor of this view is the location of the disease often on a definite strip of bark, a condition which gives the appearance of the exposure of a portion of the branch to some external injury of the sort mentioned. The question, however, can only be conclusively

⁴ Rehm, H. In Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. 1st: 98. 1896.

⁵ Fries, E. Systema mycologicum 2: 573. 1822.

⁶ Saccardo, P. A. Sylloge Fungorum 8: 748-749. 1889.

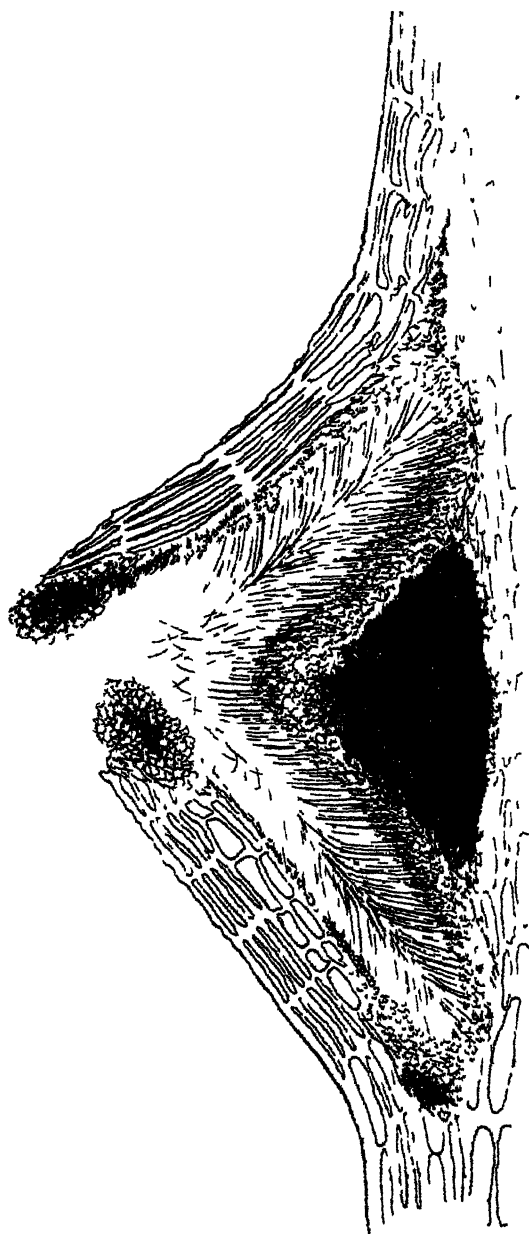


FIG 3 Cross section through pycnidium of *Coccomyces Pm* (Alb & Schw) Kaust $\times 410$

settled by thorough inoculation experiments. Unfortunately, when the study of the disease was taken up, the spores were no longer viable. But it is important to note in this connection that Kock⁷ records a case of apparent parasitism on the Scotch pine (*Pinus sylvestris* L.) due to *Coccophacidium Pini*, a name which, as has been stated, is synonymous with *Coccomyces Pini*.

HEART ROT. *Trametes Pini* (Brot.) Fr.

A case of the disease of white pine caused by this fungus, well known to be very destructive, was observed near Fairfield Lake, Jackson County, North Carolina. A large living tree about four feet in diameter, breast high, had recently been blown over, and examination of the interior of the trunk showed the wood to be composed of the characteristic dote resulting from decomposition by the mycelium of *Trametes Pini*. Although no



FIG. 4. Old fruiting body of *Coccomyces Pini*, after shedding of the spores $\times 60$

FIG. 5. Fruiting bodies of *Lophodermium brachysporum* Rostrup on leaves of *Pinus Strobus*. Natural size

fruiting bodies were found, the white spots distributed rather regularly through the wood rendered the identity of the fungus easily recognizable. This case was a good example of the way in which a fungus causing heart rot can indirectly bring about the death of a tree by weakening its mechanical support, and thus render it susceptible to windfall.

LEAF BLIGHT. *Lophodermium brachysporum* Rostrup.

Leaves on which this fungus occurred were at first light yellow, turning to a light reddish brown; in the final stages, a deep brown, which occasionally takes on a grayish cast. The fungus is characterized by its smooth and shining, black fruiting bodies, elliptical in outline, elongated parallel

⁷ Kock, G. Ueber ein scheinbar parasitares Auftreten von *Coccophacidium Pini* auf Kiefer Oesterr. Forst- u. Jagdztg. 28. 33. 1909.

with the long axis of the leaf, and arranged at more or less regular intervals along the leaf, usually on its outer surface: i.e., that surface which is oriented toward the exterior of the leaf fascicle (fig. 5). On examination with a hand lens each fruiting body is seen to be perforated, also parallel to the long axis of the leaf, by a narrow median slit whose edges approach so closely

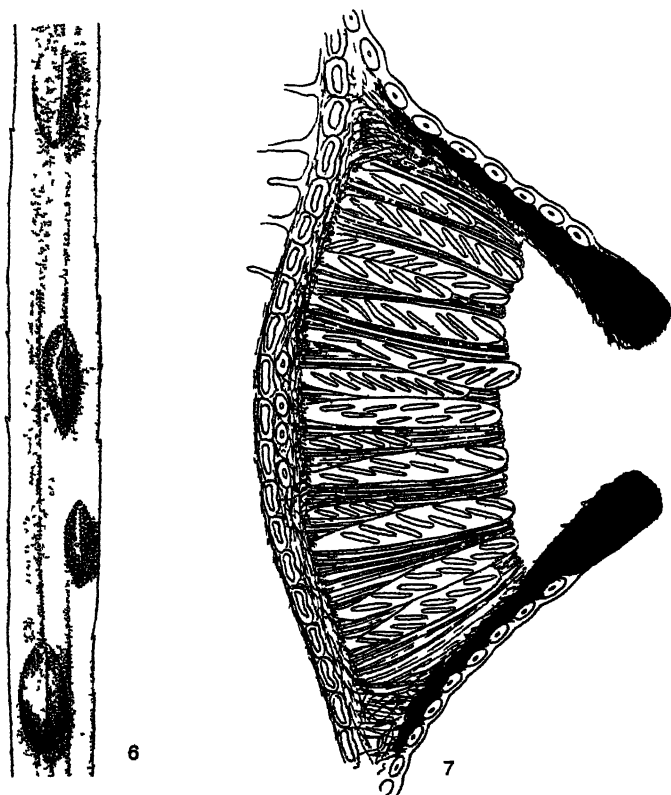


FIG. 6. Fruiting bodies of *Lophodermium brachysporum* on leaves of *Pinus Strobus*. $\times 20$.

FIG. 7. Cross section through apothecium of *Lophodermium brachysporum* Rost-rup. $\times 250$.

that the opening into the interior is almost imperceptible to the naked eye (fig. 6).

A cross section through such an apothecium is shown in figure 7. The club-shaped, sessile asci, in our specimens averaging $110 \times 16\mu$, are plentifully intermingled with filamentous, septate paraphyses, which also line

the wall of the apothecium up to about the height of the asci. Tubeuf⁸ has figured and described the paraphyses as being clavate at the apex, but our material shows besides the clavate ending a variety of other terminations, all occurring in the same apothecium (fig. 8b).

Externally the species resembles very strongly *Lophodermium Pinastri* Schrad., the well-known "schüttepliz," which has caused so much destruction in Europe. But from its comparatively short spores it is readily distinguishable from *L. Pinastri*, the spores of which are filamentous, arrange side by side, and extend nearly the length of the ascus. The mature spores are said to be at length two-celled, but only one cell appeared in our speci-

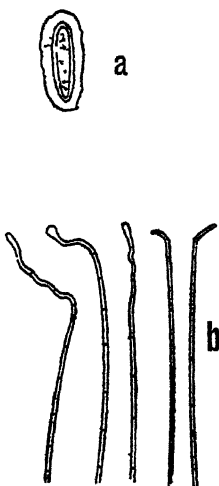


FIG. 8. a. Spore, showing mucilaginous wall. b. paraphyses. $\times 380$.

mens, although the apothecia seemed mature. Fron⁹ figures and describes them as containing four cells. The mature spore, as Tubeuf¹⁰ has described and figured, is surrounded by a thick sheath of slime (fig. 8a). Exclusive of this sheath the spores averaged $24 \times 3.25\mu$. They are normally borne in two rows in the ascus, but this double row, when viewed laterally, of course appears as a single one.

It is the writer's belief that this species is identical with *Hypoderma Desmazierii* Duby, which was collected in France on leaves of various pines

⁸ Tubeuf, C. von. Beitrage zur Kenntniss der Baumkrankheiten, p. 36. Berlin, 1888.

⁹ Fron, G. Maladie du Pinus Strobus déterminee par Lophodermium brachysporum Rostrup. Bull. Soc. Myc. France 27: 44-46. f.1. 1911.

¹⁰ Tubeuf, loc. cit., p. 36.

by Desmazières. Although, unfortunately, Duby¹¹ gave no measurements, his description and figures tally closely with the fungus in question. Moreover, the spore measurements given for *Hypoderma Desmazierii* by Ellis and Everhart,¹² 15–22 x 2.5–3 μ , are very close to ours, and it is important to note that they differ very little from those of Saccardo¹³ and Rostrup¹⁴ for *Lophodermium brachysporum*.

Briefly, the nomenclatural history of *Lophodermium brachysporum* is as follows: The species was described in 1883 by Rostrup.¹⁵ Later, Tubeuf¹⁶ noted the same fungus on the white pine in Germany, and in his description, published in 1888, retained Rostrup's name. But in his *Pflanzenkrankheiten*,¹⁷ published in 1895, evidently realizing that the short spores of the species are more characteristic of the genus *Hypoderma*, he changed the name to *Hypoderma brachysporum* (Rostrup) Tub. Finding, however, as he says later, (1897),¹⁸ that there already existed a *Hypoderma brachysporum* described by Spegazzini¹⁹ in 1887, and growing on the leaves of a species of *Berberis*, he renamed the species *Hypoderma strobicola*. In 1896, however, Rehm,²⁰ in disregard of this species of Spegazzini, had republished the description of the species under the name *Hypoderma brachysporum* Rostrup. Recently, Tubeuf²¹ (1908) has again noted the fungus under the name *Hypoderma* (*Lophodermium*) *brachysporum*. Since the species of Spegazzini is valid, and has priority, reference to our fungus as *Hypoderma brachysporum* is contrary to the rules of nomenclature. But its short spores place it more properly in the genus *Hypoderma* than in *Lophodermium*. It would seem advisable, therefore, if this is the same fungus as that described by Duby, to revive his earlier name. A final decision of the question, however, must rest upon a careful comparison of our form with

¹¹ Duby, J. E. Mémoire sur la tribu des Hystérinées de la famille des Hypoxylés (Pyrénomycètes). Mem. de la Soc. de Phil. de Genève 16: 15–70. pl. 1–2. 1862.

¹² Ellis and Everhart. Pyrénomycètes, 713. 1892.

¹³ Saccardo, P. A. Sylloge Fungorum 9: 1125. 1891.

¹⁴ Rostrup, E. Fortsatte Undersogelser over Snyltesvampes Angreb paa Skovtraernes (med system Trosnit). Tidsskrift for Skovbrug 6: 199–300. 1883.

¹⁵ Rostrup, E. loc. cit.

¹⁶ Tubeuf, C. von. loc. cit.

¹⁷ Tubeuf, C. von. Pflanzenkrankheiten durch kryptogamen Parasiten verursacht, p. 247. 1895.

¹⁸ Tubeuf, C. von, and Smith, W. G. Diseases of Plants Induced by Cryptogamic Parasites, p. 233. Note. 1897.

¹⁹ Spegazzini, C. Fungi Fuegiani. Boletín de la Academia nacional de Ciencias de Córdoba 11: 116. 1887.

²⁰ Rehm, H. Ascomyceten, in Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz 13: 1211. 1896. (Second edition.)

²¹ Tubeuf, C. von. Die Nadelerschütte der Weymouthskiefer, ein Beitrag zur Kenntnis der Krankheiten der Exoten. Naturw. Zeitschr. f. Land- u. Forstw. 6: 326–330, f. 3. 1908.

the type specimens of *Hypoderma Desmazierii* Duby, which the writer has not yet been able to obtain.

Hypoderma Desmazierii Duby has been collected in this country by Peck and Gerard²² and by Dearness in Canada.²³ Recently, Clinton²⁴ has noted it as doing some damage to the leaves of the pitch pine (*Pinus rigida* Mill.).

The fungus associated with the leaf blight treated in this paper was observed to be of common occurrence on a four or five year old plantation of white pine near Highlands, North Carolina, and also on a somewhat older plantation near Fairfield Lake, North Carolina. The same disease has also been observed this winter, (January, 1913), on a fourteen year old plantation near New Haven, Conn.

As far as the writer can ascertain, no infection experiments have as yet established the parasitism of *Lophodermium brachysporum* Rostrup. On the nearly related species, *Lophodermium Pinastris* (Schr.) Chev., however, Prantl²⁵ demonstrated parasitism in 1877 by infection experiments, and recently Haack,²⁶ in a thorough study of the "schüttepilz," has confirmed Prantl's results. In the case already referred to of the disease caused by *Lophodermium brachysporum* near New Haven, it often happened that one or more short sections of the leaf were attacked, in which the yellower color of the diseased portions stood out as distinct bands, in marked contrast to the clear green of the healthy parts of the leaf. This condition was not observed in North Carolina, possibly because the disease there had progressed beyond this point. Without enlarging on this fact, it is sufficient to state that it would seem to indicate a condition of parasitism. The writer hopes, with this fresh New Haven material, to be able soon to carry on infection experiments.

As to the amount of damage caused by this fungus Rostrup²⁷ states that it is a dangerous parasite on the white pine in Denmark. Tubeuf,²⁸ in 1888, described the disease as causing considerable damage in Germany, and recently²⁹ has issued a note of warning to German foresters to beware of its presence.

That the fungus also attacks the main stems of seedlings and the twigs of larger trees is generally accepted by European investigators, such as Ros-

²² Saccardo, P. A. Sylloge Fungorum 2: 786. 1883.

²³ Ellis and Everhart. loc. cit.

²⁴ Clinton, G. P. Conn. Agr. Exp. Sta. Rept. 1906: 319. May, 1907.

²⁵ Prantl, K. Hysterium Pinastris Schrad. als Ursache der Schuttekrankheit der Kiefer. Vorläufige Mittheilung. Flora, N. S., 35: 333-336. 1877.

²⁶ Haack. Der Schuttepilz der Kiefer. Zeitschr. f. Forst-u. Jagdwesen. 43: 329-357; 393-423; 481-505, pl. 1. 1911.

²⁷ Rostrup, E. loc. cit.

²⁸ Tubeuf, C. von. (1888), loc. cit.

²⁹ Tubeuf, C. von. (1908), loc. cit.

trup, Tubeuf, Haack, and Fron.³⁰ The last mentioned states definitely that the mycelium descends from the leaves into the branches, at first into the cortical zone, chiefly in the large resin ducts there, then into the medullary rays, the resin ducts of the wood, and extends even into the tracheids of the spring wood. By its presence it soon puts a stop to the activity of the cambium and so brings about the dessication and death of the branch. Spaulding,³¹ who mentions the frequent occurrence of the fungus on the leaves of the white pine in this country, has also recorded it as the causal

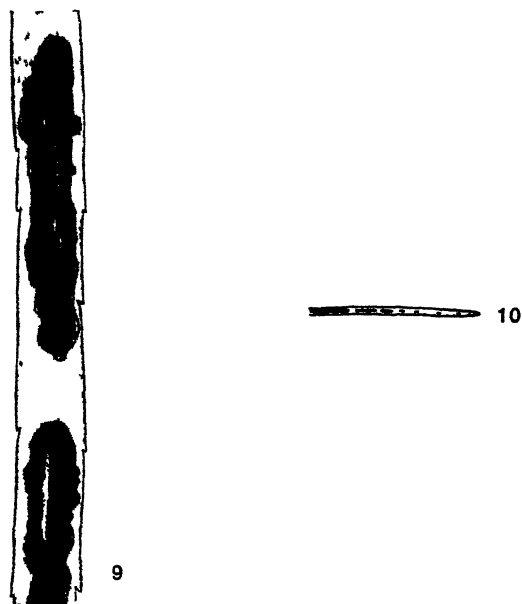


FIG. 9. Abnormal fruiting bodies (?) on leaf of *Pinus Strobus* $\times 20$.

FIG. 10. Showing transition from abnormal to normal form of fruiting body. Natural size.

organism in a twig blight of the same species. Stevens and Hall,³² in treating of the diseases of the white pine, include the twig and leaf blight caused by this fungus.

Among the specimens collected by the writer, those from the young plantation near Highlands, North Carolina, showed in many cases a dying out of the terminal portion of the shoot, which was completely defoliated, but

³⁰ Fron, G. Loc. cit.

³¹ Spaulding, Perley. The present status of the white pine blights. U. S. Dept. Agr. Bur. Pl. Ind. Cir. 35: 1-12. August 1909.

³² Stevens F. L. and Hall J. G. Diseases of economic plants. pp. 445-446. 1910

showed diseased leaves still attached to the lower more healthy part. The bark in the diseased region was slightly swollen and exhibited a peculiar granular appearance, chiefly caused by what looked to the naked eye like an abnormal lenticel development. Cross sections through this diseased part revealed the presence of mycelium, but whether or not this belonged to the *Lophodermium brachysporum*, could not be definitely determined.

Although the two places in North Carolina above mentioned were the only stations where the disease was observed in the southern Appalachians, the amount of damage done was considerable, especially on the young four or five year old plantation near Highlands.

In connection with the *Lophodermium brachysporum* associated with the leaf blight there commonly occurred a form which appeared to agree with the description and exsiccati of another fungus: i.e., *Hypoderma lineare* Peck (figs. 9 and 10). This may, however, be nothing but an abnormally developed form of *Lophodermium brachysporum*. The writer bases this belief on the following considerations:

1. Cross sections showed the fruiting body to be essentially the same in structure, and in location between epidermis and hypodermis of the leaf, as in *L. brachysporum*.

2. The fruiting bodies were uniformly abortive, i.e., contained no asci.

3. The fruiting bodies, although in general linear in outline, exhibited a more or less irregular and variable margin, exterior surface and opening, (fig. 9), as if developed in an abnormal way.

4. The fruiting bodies sometimes occurred on the same leaf with the normal fruiting bodies of *L. brachysporum*, with apparently gradual transitions into the normal form (fig. 10).

YALE UNIVERSITY

NEW HAVEN, CONNECTICUT

REVIEW

Studies of fungous parasites belonging to the genus *Glomerella*. Shear. C. L. and Wood, Anna K. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 252, 110 pages, 18 plates, 1913.

The primary object of the investigation has been to determine the life histories and the relationships of the forms of *Gloeosporium* and *Colletotrichum* found upon the same hosts or on different ones. Some hundreds of species of these fungi have been described, but a critical monograph of either of the genera has never been published. The species have hitherto been based upon slight differences in spore characters, the appearance of the part affected, occurrence upon different hosts or even on different parts of the same host.

The writers base their systematic work upon the following premises: where no fairly constant morphological characters separate the forms growing upon different parts of the same host, these forms should be referred to the same species; where the forms occur on different hosts, but still show no reasonably constant characters for their separation, they should also be regarded as one species. Their separation even as so-called "physiological species" must depend upon a sufficient number of successful cross inoculations which show the fungi will not pass from one host to another.

In the present publication the results of studies of forms from 45 different hosts are given. These investigations began in 1904 and have continued to date. They have included pure culture work with each form; pedigree, pure-line, single-spore cultures with both conidia and ascospores for many generations; morphological studies; physiological studies of the effect of different media, temperature, etc., upon the production of ascospores, and other variations of the fungi; and transfers from host to host. No cytological work has been done.

It was found that the variability of the same fungus from the same host is so great that no character, either morphological or physiological, seems to be well fixed, and many forms intergrade so intimately that there is no specific difference to be found. The perfect stages of the forms from 36 of the hosts have been obtained, a considerable number being here reported for the first time.

The 36 forms from as many different hosts have been reduced to 3 species: *Glomerella cingulata* (Stonem.) S. & v. S., *G. gossypii* Edge. and *G. lindemuthianum* Shear n. comb.

The two latter are apparently quite distinct and are limited in their host plants. The first includes the great mass of fruit- and leaf-inhabiting

forms which were investigated, including the well known apple bitter rot fungus.

It was found that apparently healthy leaves of many different plants in the greenhouse developed the fungus when the exterior was sterilized with corrosive sublimate and the leaves placed in sterilized moist chambers. Great variation was found in the production of asci: when cultures were made from the same leaf or fruit, sometimes one ascus produced only conidia, while another produced asci. There are apparently very distinct ascus-producing strains of the same fungus which will transmit this ability through a long series of generations. In no case was a "conidial" strain found to later develop asci in pure cultures, nor were there any evidences of sexual union between strains, such as Blakeslee demonstrated for *Mucor*.

The extensive cross inoculation experiments between hosts show the extreme readiness of these fungi to attack the most varied hostspecies. It was found that strains of the fungus from the same host vary in virility.

The reviewer's experience with the apple bitter rot fungus some years ago, when pure cultures of the fungus were successfully inoculated onto such diverse hosts as pear, squash and *Crataegus* fruits leads him to believe that the writers have adopted the only course open in revising these species. Their publication bears evidence of the great amount of careful and painstaking labor done in these investigations. The absence of any evidence of the permanent change of any single character beyond its usual variations is significant, as it would seem that such an occurrence might take place in a group of this kind if at all. On the other hand, distinct variations were secured in the pedigree, single-spore, pure-line cultures; however these did not persist but soon disappeared. This is believed by the authors to show that they should be considered as fluctuating variations rather than what are usually called mutations.

The writers conclude that the production of asci is a hereditary racial character which is not dependent primarily upon special conditions of nutriment or environment. The large amount of data, which has been accumulated by numerous investigators since Atkinson first demonstrated the existence of an ascogenous stage for a *Gloeosporium*, has been critically reviewed and utilized. Where the writers' results differ from those of previous investigators, that fact is plainly stated. A list of about 10 papers and 18 plates, which are indispensable to a good understanding of the text, close the bulletin. It is not too much to say that the bulletin is full of suggestions to all who have to do with the investigation of fungous parasites. It makes a distinct advance in our knowledge of the evolution of new races of fungi and clears the field of a number of erroneous theories regarding it. The caution with which general conclusions have been drawn is not the least commendable feature of the publication.

PERLEY SPAULDING.

PHYTOPATHOLOGICAL NOTES

Destructive effects of Trametes pini and Echinodontium tinctorum. In the living tree a heartwood destroying fungus seldom extends its activities beyond the main body of the trunk. In this connection some very interesting variations have been observed by the writer in the case of *Trametes pini* and *Echinodontium tinctorum*. The former fungus after decomposing the greater part of the heartwood of living western red cedar has been found to extend its ravages into the limbs and smaller branches of the tree. Every branch in one critically examined specimen down to a diameter of 1 inch or less was found to have the heartwood destroyed by the fungus, even the smaller lateral limbs of the main infected branch being attacked. *Trametes pini* is very common on the western red cedar but is not the cause of the universal heart rot of this species.

A condition similar to that noted above has been observed for *Echinodontium tinctorum* in western hemlock and grand fir. Bell shaped sporophores of this fungus have been collected on branches of living trees, 5 to 8 feet out from the main trunk. The smaller lateral branches were likewise attacked.

These points are of interest in as much as they illustrate the unparalleled activity of some wood rotting fungi in the heavily infected forests of the northwest.

JAMES R. WEIR.

Personals. 'Dr. Harry B. Humphrey, recently Professor of Botany in the State College at Pullman, Washington, was appointed Pathologist in the office of Grain Investigations of the Bureau of Plant Industry, U.S. Department of Agriculture, March 1, 1913. Dr. Freda M. Bachmann, last year assistant in botany and plant pathology, University of Wisconsin, is now at Milwaukee-Downer College in charge of the work in botany and bacteriology.

PHYTOPATHOLOGY

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NUMBER 3

INTERNATIONAL PHYTOPATHOLOGY AND QUARANTINE LEGISLATION¹

W. A. ORTON

INTRODUCTION

It is the purpose of this paper to discuss the problems of international phytopathology with especial reference to the needs developed in applying legislative means for the control of plant diseases, and to present for the information of the Society an outline of the new Federal Plant Quarantine Act.

Until a few months ago there were no laws conferring on the government authority to take precautionary measures against the introduction into the United States of foreign insects and plant diseases or to restrict the spread of pests already here. Trade in nursery stock and plant products was then governed only by the laws of the several states, and although most of these were maintaining some kind of inspection service, there were many gaps through which diseased material could slip. This situation was in striking contrast to the prohibitory laws enforced for many years in other countries, particularly against American plants, and the incalculable losses suffered by American agriculture and horticulture from the San José scale, the gypsy and brown-tail moths, peach yellows, and other troubles emphasized the need for action.

The persistent efforts of the last fifteen years resulted last summer in the passage by Congress of the Simmons Bill, which became the Plant Quarantine Act, August 20, 1912. The essential features of the law are outlined below. The full text with the regulations is printed in a circular of the Department of Agriculture.²

¹ Read at the Symposium on International Phytopathological Problems before the American Phytopathological Society, January 2, 1913.

² Circular 44, Office of the Secretary, U. S. Dept. of Agric. Sent free upon application. See also Notices of Quarantine, Nos. 1 to 6 inclusive, and Quarantine Decisions, Nos. 1 and 2.

SCOPE OF THE LAW

The law does not impose a general quarantine against all plant diseases, but only against those which, after having been shown to be new and dangerous, are made the subject of special quarantine orders. Regulations are provided for the importation and inspection of nursery stock, which the law defines to include "all field-grown florists' stock, trees, shrubs, vines, cuttings, grafts, scions, buds, fruit pits, and other seeds of fruit and ornamental trees or shrubs, and other plants and plant products for propagation, except field, vegetable, and flower seeds, bedding plants, and other herbaceous plants, bulbs, and roots."

This definition may be extended by the Secretary of Agriculture to include any of the excepted plants or plant products whenever it shall appear that their unrestricted importation might result in the entry of injurious insects or plant diseases. This has been done in several cases by the quarantine orders mentioned later.

PERMITS

In order that all imported nursery stock may be inspected, the law provides machinery to insure that notification of every shipment is sent to the proper inspection officer. The importer must first secure a permit from the Department of Agriculture, which authorizes him to import nursery stock from a specified firm and locality for a specified period, usually until June 30 following. If this permit is lacking, the customs officer refuses to admit the goods to entry. The importer need not specify in his original application the character and quantity of the stock, but immediately upon its arrival he must give the customs officer, for transmission to the Department of Agriculture, a statement of this nature, including destination. He must mail a copy at the same time to the inspector in the state of destination. The Department of Agriculture also notifies the state inspector, who reports back the result of his examination.

INSPECTION

All inspection of nursery stock, except that from countries maintaining no inspection service, and consequently unable to grant the certificates required by our law, is at point of destination, and is performed by state officials. The law does not authorize federal port of entry inspection, except as hereafter noted.

It is a pleasure to acknowledge the hearty support and coöperation that has been given by the state officials everywhere. As an indirect effect of the new law, several states have strengthened their inspection service

by extending the powers of their inspectors and granting additional financial support.

FOREIGN CERTIFICATES

The law requires that no nursery stock shall be admitted unless "accompanied by a certificate of inspection, in manner and form as required by the Secretary of Agriculture, of the proper official of the country from which the importation is made, to the effect that the stock has been thoroughly inspected, and is believed to be free from injurious plant diseases and insect pests."

During the present season, the forms of certificates previously in use have been accepted, but after July 1, 1913, it will be required as a requisite for customs entry, that "the invoice be accompanied by an original certificate, and each container bear a copy-certificate, issued by a duly authorized official of the country from which it is exported, stating that the nursery stock *covered by the certificate* has been thoroughly inspected by him or under his direction and found, or believed to be, free from injurious plant diseases and insect pests. Nursery stock exported between October 1 and May 31, shall be inspected on or after the first of October, and stock exported between June 1 and September 30 shall be inspected at the time of packing."

"Nursery stock from countries which do not maintain official nursery stock inspection will be admitted into the United States *only for experimental purposes and in limited quantities*, under special permit, through ports designated therein. Such nursery stock shall not be delivered to the importer or consignee until it has been examined by an inspector of the Department of Agriculture and found to be free from plant diseases and insect pests, as defined in the Act." It is provided, however, that if the stock can be cleaned by treatment, this may be done, and a regulation defines the procedure to be followed.

This section of the regulations is of especial interest to the phytopathologists and those interested in plant introduction, since it is from countries having no inspection services that we are seeking many new plants for experimental purposes. However great may be the future promise from such introduction, there is equal danger that they may bring with them hitherto unknown pests, which, like the San José scale, may spread to other crops. The plan to limit and control such introduction should, therefore, receive general support.

PLANT QUARANTINES

Authority is granted by the law to prohibit the importation of any plant or plant product whenever necessary to prevent the introduction of

"any tree, plant, or fruit disease or of any injurious insect, new to or not theretofore widely prevalent or distributed within and throughout the United States." Under similar circumstances, a domestic quarantine may be issued restricting interstate trade in the plants or products affected.

The following Quarantine Notices have been issued:

No. 1, dated September 16, 1912, prohibits the importation of four species of pine (*Pinus strobus* L., *Pinus monticola* Dougl., *Pinus lambertiana* Dougl., and *Pinus cembra* L.) from Great Britain, France, Belgium, Holland, Denmark, Norway, Sweden, Russia, Germany, Austria, Switzerland, and Italy, on account of the white pine blister rust (*Peridermium strobi* Kleb.) This order has since been made more stringent. Cf. Quarantine Notice No. 7.

No. 2, dated September 18, 1912, prohibits the movement from Hawaii into or through any other part of the United States of thirty fruits and vegetables liable to infestation by the Mediterranean fruit fly (*Ceratitis capitata*).

No. 3, dated September 20, 1912, prohibits the importation of potatoes from Newfoundland; the islands of St. Pierre and Miquelon; Great Britain, including England, Scotland, Wales, and Ireland; Germany; and Austria-Hungary, on account of the potato wart (*Chrysophlyctis endobiotica*, Schilb.)

No. 4, dated November 5, 1912, quarantines the districts in New England infested with gypsy moth and brown-tail moth, and provides regulations for the movement of plants and forest plant products therefrom.

No. 5, dated January 15, 1913, prohibits the introduction into the United States from Mexico of seven fruits liable to infestation by the Mexican fruit fly (*Trypeta ludens*).

No. 6, dated March 1, 1913, quarantines certain districts in California, Arizona, and Texas, on account of the date palm scale insects *Parlatoria blanchardi* and *Phoenicococcus marlatti*, and provides regulations for the treatment and interstate transportation of date palms.

No. 7, dated May 21, 1913, extends the quarantine against the White Pine Blister Rust by prohibiting the importation of all 5-leaved pines from all countries of Europe and Asia.

IMPORTATIONS FOR SCIENTIFIC PURPOSES

The Department of Agriculture is authorized to import nursery stock for experimental or scientific purposes, subject to conditions and regulations prescribed by the Secretary. It has been arranged to have such importations handled by the Office of Foreign Seed and Plant Introduction, in charge of Mr. D. G. Fairchild, and a thorough inspection for insects and diseases made.

Other institutions desiring to import plants for scientific or experimental purposes from countries not under quarantine, may secure permits in the same manner as private firms.

Under an amendment passed March 3, 1913, any class of plants the importation of which is prohibited by quarantine may be brought in for experimental or scientific purposes by the Department of Agriculture only. Special safeguards are thrown by Departmental regulations around such importations.

SHIPMENTS BY MAIL AND PARCELS POST

There has been hearty cooperation by the Postmaster-General in adjusting the postal service to the new quarantine law. It was early found impracticable to inspect at destination small mail shipments of nursery stock, and these frequently came without the certificates and marking required. It is evident that the danger from mail shipments is in many ways greater than from larger consignments of nursery stock. The Post Office Department has recently issued an order, effective July 1, 1913, which renders nursery stock unmailable in the International Parcels Post, except when intended for and addressed to the United States Department of Agriculture.

The domestic mails are open to nursery stock accompanied by an inspection certificate and marked to show nature of contents and name and address of sender. Other orders³ of the Postmaster-General assist in the enforcement of the special quarantines by rendering certain Hawaiian fruits unmailable and by requiring special certificates for certain plants grown within the area covered by the gypsy and brown-tail moth quarantine.

PUBLIC HEARINGS .

A valuable feature of the law is the requirement that public hearings be held, after due notice, before the promulgation of an order modifying the definition of nursery stock, or placing a foreign or a domestic quarantine.

PENALTIES

Violation of the law is a misdemeanor, to be punished by a fine not exceeding five hundred dollars or by imprisonment not exceeding one year, or both. Permits may be cancelled and further permits refused, for the

³ Nos. 6655, November 16, 1912; 6674 and 6675, November 27, 1912; and December 4, 1912. See also, Marlatt, C. L., The federal plant quarantine act, *Journ. of Econ. Entomology* 6: 133-142. 1913.

importation of the products of any grower or exporter who has knowingly shipped into the United States any nursery stock or other plants or plant products the importation of which is forbidden, or who fails to give either of the notices required, or gives a false notice, or knowingly mislabels any nursery stock with intent to evade any provision of the Act or of any regulation thereunder.

THE FEDERAL HORTICULTURAL BOARD

For the enforcement of the Plant Quarantine Act there is appointed by the Secretary of Agriculture a Federal Horticultural Board, of five members appointed from the Bureau of Entomology, Bureau of Plant Industry, and the Forest Service. As first organized the Board consisted of C. L. Marlatt, Chairman, A. F. Burgess, W. A. Orton, Vice Chairman, Peter Bisset, and Geo. B. Sudworth. Mr. Burgess was succeeded on January 21, 1913, by W. D. Hunter, and Mr. Bisset on April 3, 1913, by A. V. Stubenrauch. The headquarters are in Washington. In addition to the clerical force there is an entomological inspector, E. R. Sasser, and a pathological inspector, Perley Spaulding. In the field work much assistance is rendered by state officials, acting as collaborators of the Board.

INTERNATIONAL PROBLEMS IN QUARANTINE ADMINISTRATION

Perhaps no country is more concerned than the United States in the international problems involved in the suppression or control of plant diseases. In bringing a new continent under cultivation we are establishing agriculture under many diverse conditions of soil and climate. We are adding to the cultivated plants of the new world all that may be introduced from the old world, and we are breeding new crops and new varieties, into which we are weaving hitherto uncultivated or unknown strains from distant climes.⁴

Furthermore, during the pioneer stages of our agriculture wide areas have been continuously cropped without observing the rotation practices into which experience has led the older nations, thus favoring the development and spread of parasites. In these and in other ways, we are disturbing the equilibrium which nature maintains between plants and their parasites. We have brought in many of the common diseases of Europe, which have proven more virulent here than at home, and we have established here the culture of European plants which have become attacked

⁴Swingle, Walter T. The fundamentals of crop improvement. U. S. Dept. of Agric. Bur. of Pl. Ind. Cir. 116. March 8, 1913.

by American diseases.⁵ Both of these processes will be repeated in the future, but it is our problem to reduce the spread of diseases to a minimum.

IS PROHIBITION BETTER THAN REGULATION?

One procedure, followed by several countries, is to prohibit all plant importations. This policy, though perhaps the most effective safeguard, has not prevented the entry of some pests, while it has restricted development. We appear on the other hand to be committed to a policy of regulation, for the people of the United States prefer at present to purchase freely the products of European nursery skill and import their fruit and rose stocks, bay trees, azaleas, bulbs, etc., if it can be done without serious risk of future injury. The imports of such nursery stock into the United States are quite large.

It is at this point that the difficulties involved in protecting ourselves by our own inspection service emphasize themselves. It is utterly impracticable, under present conditions, to examine at the port of entry the imported nursery stock, coming as it does in great volume during a few months, when the dockage facilities are overcrowded. The perishable nature of the stock and the expense involved in repacking constitute additional very serious obstacles. The time to examine stock is when it is dug and packed. An efficient inspection in the country of origin will greatly reduce our danger, but at this point the need of closer international relations becomes apparent, for the inspection should be not only against insect pests and diseases in general, but specifically to insure freedom from certain of the more dangerous enemies such as the brown-tail moth.

Some countries, notably Holland, already maintain effective nursery inspection, but in most cases an improvement is to be hoped for. The effect of our Plant Quarantine Act and the action of the Board in reporting back to the country of origin cases of infestation discovered by the American inspectors, has already been marked in several instances. The foreign certificates will ultimately stand for clean nurseries.

There is great need for international research to strengthen this work, for we are at present distressingly ignorant of pathological conditions in other countries. It would be possible to determine the dangerous character of certain parasites in time to take measures to prevent their introduction. The writer has been assured by competent authority that there are insects in Europe more dangerous to us than the gypsy moth, and he

⁵ Orton, W. A. The development of farm crops resistant to disease. U. S. Department of Agriculture, Yearbook 1908: 453-464. 1909. Orton, W. A. The development of disease-resistant varieties of plants. IV^e Conference internationale de genetique, Paris, 1911, pp. 247-265, figs. 9, 1913.

is convinced that a similar statement may be made regarding fungus troubles. Probably the danger of bringing pests from the Orient is even greater.

The organization of research along international lines should be on a broad basis, for as pointed out by Shear⁶ the pathological conditions differ greatly and the climatic factors are of great importance. Diseases that are of little consequence in Europe may be serious in America, and vice versa. An interchange of visits between European and American workers would throw these points into bolder relief, but a further step is highly to be desired, namely, the formation of an International Committee on Phytopathology, for the purpose of securing closer relationships between the scientific workers in the several countries and to promote research along lines of international interest. Such a committee might stimulate the organization of Plant Disease Survey agencies in each country, to record the geographic distribution of the diseases of plants and their annual prevalence. Reports on the losses caused would enable the economic importance of the subject to be better understood. Epidemic outbreaks should be studied in relation to the weather, crop distribution, and other factors. Data should be gathered bearing on the problems of parasitism, especially in its relation to the adaptation of plants to their environment and the disease resistance or susceptibility of varieties. The coördination of meteorological data should be sought for, so that direct comparisons bearing on plant pathology may be made. Special observations, such as the relative atmospheric humidity in comparison with soil moisture, might be of great service.

It will be noted that emphasis has been placed on the research phases rather than on the idea of governmental agreements for the regulation of trade. The latter viewpoint seems to have been in the minds of those present at the International Congress of Comparative Pathology last September,⁷ where an international conference was urged for the purpose of formulating an international agreement along the lines of the Berne Convention. The latter related to the control of Phylloxera by the establishment of quarantined areas, restriction of trade in products of the vine, certification of freedom of plants from disease, etc. It has later been proposed by Cuboni⁸ that the terms of this convention be extended to other plants than the grape. In so far as this would provide a better means

⁶ *Phytopathology* 3: 61. April, 1913.

⁷ *L'entente internationale pour la lutte contre les maladies des plantes*. Jardin. 25: 354. Paris, December 5, 1912.

⁸ Cuboni, Guiseppe. The basis of an international agreement for the control of plant diseases. Bureau of Agricultural Intelligence and of Plant Diseases (Rome). Third year. Bulletin 11: 2349-2354. November, 1912.

for the inspection and certification of nursery stock, it is to be recommended. Let us hope, however, that the need for more knowledge will not be overlooked. The present is a period of general interest in this subject on both sides of the Atlantic, and the outlook for action of a favorable nature is most gratifying. May we not assure our colleagues of other countries of our active support of the movement?

HERPOTRICHIA AND NEOPECKIA ON CONIFERS

W. C. STURGIS

WITH PLATES XII AND XIII

In the course of a trip through northern Wyoming in the late summer of 1902 I was struck with the extraordinary prevalence of a fungus, unfamiliar to me, infesting the leaves and twigs of *Abies lasiocarpa* and *Picea Engelmanni*. The fungus occurred only on comparatively young trees from five to ten years of age and presented the appearance of a felt-like growth of dark brown mycelium spreading over and involving the leaves, often to such an extent as to hide them from view (pl. XII, fig. 4.) Later, as the leaves died and became detached from the branchlets, the whole mass of mycelium and intermingled leaves could easily be removed intact. Closer examination revealed the presence of numbers of perithecia completely immersed in the felted mycelium except for the slightly prominent ostiola (pl. XIII, fig. 1). A quantity of material was collected and dried for further study.

In September of the following year and in about the same locality I encountered a grove of *Pinus Murrayana*, the leaves of which were infested with what appeared to be precisely the same fungus, and again much material was saved (pl. XII, figs. 1-3).

On examining later the gatherings of these two seasons, I was surprised to find that, notwithstanding the striking similarity of their external appearance, they belonged to two widely separated genera. The specimens collected in 1902 on *Abies* and *Picea* proved to be *Herpotrichia nigra* Hartig, while those found in 1903 on *Pinus* were plainly referable to *Neopeckia Coulteri* (Pk.) Sacc.

Inasmuch as neither of these fungi appears to have figured at all prominently in the literature of fungus diseases in North America, and since, in addition, the synonymy of both seems somewhat confused, the following notes may be of value.

HERPOTRICHIA NIGRA Hartig.

This fungus was first reported by Hartig and was described and figured by him in the *Allgemeine Forst- und Jagdzeitung* for January, 1888. In *Hedwigia* 27: 12-15, it is referred to by the same author as occurring in Bavaria on *Picea excelsa*, *Pinus montana*, *Juniperus communis* and *J. nana*.

Hartig also states that it had been found on the last-named host in Norway.

He describes the dark-brown, matted mycelium, the immersed perithecia attaining a diameter of 0.3 mm., the asci 76 to 100 μ by 12 μ , and the spores biserial in the asci, uniseptate when immature, 4-celled later.

Hartig implies that the spores are hyaline; hence Saccardo, copying the original description writes (Syll. Fung. 9: 858. 1891), "an potius *Enchnosphaeria*?"

Berlese (Icon. Fung. 1: 105. Tab. ciii, fig. 1. 1892) transfers the fungus to the genus *Enchnosphaeria* and questions the supposed identity of *E. nigra* and *E. pinetorum* Fuck., a supposition due to the fact that Saccardo had recorded under the latter name a fungus collected in France, which is unquestionably *Enchnosphaeria* (*Herpotrichia*) *nigra*. (Michelia 2: 596.)

Berlese's conclusion that the two are distinct is borne out by his drawings. Of this author's and Saccardo's reference of the "sterile mycelium" to *Rhacodium Therryanum* I shall speak later.

Tubeuf (Pflanzenkrankheiten, p. 215. 1895) writes "*Herpotrichia nigra*" again and gives an excellent figure of an infested branch of *Pinus*. He also figures the 3-septate, mature and germinating spores, but gives no indication that they are other than hyaline at maturity.

Finally Sorauer (Handb. d. Pflanzenkrankheiten 2: 227) condenses his predecessors' accounts of this fungus, using the original name.

I find but one reference to *Herpotrichia nigra* in American literature, (F. S. Earle in Greene's *Plantae Bakerianae* 1: 27. 1900), the reference being to a specimen gathered in Colorado. A brief sentence in Ellis & Everhart's *North American Pyrenomycetes*, p. 147, mentions the fungus, but merely by way of drawing a comparison between this species and *Lasiosphaeria* (*Neopeckia*) *Coulteri*. These authors state that the spores of the specimen of *Herpotrichia nigra* distributed by Allescher & Schnabel (Fung. Bav. No. 70) are hyaline. This statement is based on insufficient observation; as a matter of fact the spores in the specimen referred to are distinctly olivaceous when mature (pl. XIII, figs. 2 and 3).

Here, then, we have a fungus recorded but once from America, but common in Europe, occurring in France, Bavaria, Norway and Sweden on *Picea excelsa*, *Pinus montana*, *Juniperus communis* and *J. nana*; but never, be it noted, on *Abies*. It is interesting therefore, to find it occurring in great abundance on both *Abies* and *Picea* in the United States. It is further of interest to note that, whereas all previous authors appear to agree in stating that the mature spores are hyaline, and are therefore constantly tempted to throw this fungus into the genus *Enchnosphaeria*, my own observations, especially in the case of American specimens, lead me to conclude that such is not always, or even normally, the case. Thus

in the specimens distributed by Allescher & Schnabel above referred to, the spores are at first 1-septate and perfectly colorless; later they become 3-septate, but still remain hyaline though they are capable of germination at this stage; only at the extreme of maturity do they become olivaceous in color. The same is true of my specimens on *Picea*; hyaline and 2-celled when young, each cell being markedly pyriform in shape, it is only at full maturity that they become 4-celled and acquire a color rather darker than in the Bavarian specimens (pl. XIII, figs. 4 and 5). My specimens on *Abies* show a still further development, the spores while still barely differentiated in the asci being often 3-septate and dilutely fuscous, while at maturity they are as dark as in any *Chaetosphaeria* (pl. XIII, figs. 6 and 7).

Through the courtesy of Mr. C. L. Shear, of the U. S. Department of Agriculture, I have been enabled to examine a fairly large series of specimens of *Herpotrichia* on *Abies* and *Picea* collected in 1898 and the two following years in Colorado and Oregon. In such of these specimens as show mature fruit the spores are always colored when ripe, the color being more pronounced when *Abies* is the host. The series includes one specimen on *Abies concolor*, a new host for this fungus.

Herpotrichia matures its spores remarkably early in the season, considering the group to which it belongs. The Bavarian specimen above referred to was collected in June; my Wyoming gatherings were made early in September; while those collected by Mr. Shear, bear dates from August 23 to September 1. The Bavarian specimens can hardly be considered as fully mature. None of Mr. Shear's specimens show mature fruit before August 14. Mine, collected after September 1, are all mature. Both the asci and the spores of this fungus are extremely fugacious; very shortly after maturity the ostiola of the perithecia are seen to have broken away and not a trace of the former contents remains.

The mycelium of this fungus is usually sterile, so far as conidia are concerned, in the specimens which I have examined. In the Bavarian specimens however, as well as in one from Wyoming on *Picea*, there are occasionally to be found large, olive-brown, 3 to 6-septate conidia, borne singly on the erect tips of the coarse hyphae (pl. XIII, fig. 8). This fact places the mycelium hitherto known as *Rhacodium Therryanum*, in the genus *Helminthosporium*.

One further point regarding the mycelium requires elucidation. Hartig was of the opinion that the hyphae in contact with the cuticle of the host were provided with minute haustoria concerning which he writes as follows: "Die stabförmigen Saugorgane haben etwa die Grösse kräftiger Stäbchen, dringen nur bis zur Mitte oder bis zu Zweidrittel der Zellwanddicke ein, wirken aber trotzdem auf den Zellinhalt tödtend und führen dem Mycel reichliche Nahrung zu, da ohne eine solche Zufuhr die so üppige

Pilzpolsterbildung nicht recht erklärbar sein würde" (Hedwigia 27: 15. 1888). Subsequent writers seem to have shared in this opinion and Tubeuf figures these so-called haustoria in the case of both Herpotrichia and Trichosphaeria (Pflanzenkrankheiten, figs. 84 and 82). Hartig himself is surprised that haustoria which do not pierce the cell wall should, nevertheless, be able to destroy the cell contents, and his argument that the abundant development of the mycelium can not be accounted for other than by the presence of these "haustoria" seems to me futile in view of the fact that the mycelium permeates the leaf tissues throughout and causes much more profound changes in the cells of the mesophyll than in those of the epidermis (pl. XIII, fig. 9). Moreover, the fact that the mycelium separates with the utmost ease from the substratum (in making free-hand sections it is almost never that the mycelium remains in contact with the epidermal cells), and the further fact that hyphae carefully separated from the leaf surface show neither haustoria nor any trace of them, seem to militate against Hartig's theory. My opinion is that what this observer took to be haustoria are cracks produced in the very thick external walls of the epidermal cells by the killing and subsequent drying-out effects brought about by the dense mycelium. In any case this fungus affords a striking example of the destructive effects of combined epiphytism and parasitism.

The following description is compiled from American specimens.

Herpotrichia nigra (Pk.) Sacc. Perithecia spherical with slightly prominent ostiola, 0.25 to 0.45 mm. diameter, semi-immersed in a dark brown, felt-like subiculum 0.27 to 0.5 mm. thick. Asci club-shaped, 128 to 155 μ by 14 to 18 μ . Paraphyses filiform, fugacious. Ascospores irregularly biserial in the asci, elliptical, at first 1 to 3-septate, hyaline; later 3-septate, more or less constricted at the septa, pale to darker olivaceous-brown, 22 to 33 μ by 8.5 to 9 μ . Conidia borne singly on short hyphae, dark brown, 3 to 6-septate, constricted at the septa, 27.5 to 29 μ by 9 to 10 μ .

Habitat. On living leaves and twigs of *Picea excelsa*, *Pinus montana*, *Juniperus communis* and *Juniperus nana* (Europe); *Picea Engelmanni*, *Abies lasiocarpa* and *Abies concolor* (Wyoming, Colorado and Oregon).

Synonym. *Enchnosphaeria nigra* (Hartig) Berl.

Exsiccati. Rehm, Asco. Exsicc., No. 996; Allescher & Schnabel, Fung. Bavar., No. 70; Rabenhorst, Fung. Eur., No. 3961; Vestergren, Microm. Rar. Sel., No. 600.

NEOPECKIA COULTERI (Pk.) Sacc.

In the introduction to this paper I mentioned the fact that subsequently to the finding of Herpotrichia on Abies and Picea, I secured a further supply, from much the same locality, of what appeared to be the same

fungus on *Pinus Murrayana*. It presented precisely the same dark-brown, broadly spreading, felt-like mycelium, showing similar immersed perithecia, and causing the same killing and matting-together of the leaves (pl. XII, figs. 1-3; pl. XIII, fig. 10).

Microscopic examination of this fungus showed that in every detail it corresponded exactly with *Herpotrichia nigra* except in the case of the spores. Whereas in the *Herpotrichia* they are more or less biseriate in the asci and, at maturity, 4-celled and olivaceous, in the fungus on *Pinus* they are strictly uniseriate, 2-celled, and becoming very dark brown as they mature (pl. XIII, figs. 11 and 12). This fungus was originally described by Mr. C. H. Peck under the name *Sphaeria Coulteri* (Hayden, Rep. U. S. Geol. Survey. 1872, p. 792). Eight years later Cooke described, as *Lasiosphaeria acicola*, Cke., a specimen "collected and characterized by Madame Libert, now in the Herbarium of the Botanic Gardens at Brussels." It is noted as occurring "on pine leaves, Rocky Mountains (Dr. Lyall in Herb. Kew)" (*Grevillea* 8: 87. 1880). Cooke's description is sufficient to identify this fungus with that previously described by Peck.

Later Saccardo, through some strange misconception, transferred this species to the genus *Enchnosphaeria*, but adds the query "an potius *Eriosphaeria*?" (*Syll. Fung.* 2: 207. 1883). He was evidently misled by the external resemblance of this American fungus to the common European *Herpotrichia nigra*, the spores of which were originally described as hyaline; then, discovering that the spores of the former were 2-celled, he suggested writing *Eriosphaeria* for *Enchnosphaeria*, both of which names are inapplicable. In the previous volume of the *Sylloge*, however (1: 727. 1882), Saccardo had inserted Cooke's *Lasiosphaeria acicola*, but had questioned its proper generic place, writing *Amphisphaeria? acicola* (Cooke) Sacc. The question mark is more than justified; the fungus is certainly not an *Amphisphaeria*. Finally this same writer (*Bull. Torrey Bot. Club* 10: 127. 1883) transfers his *Enchnosphaeria Coulteri* (Pk.) to his new genus *Neopectia* and it becomes *N. Coulteri* (Pk.) Sacc. Just why Ellis & Everhart (*N. Amer. Pyrenomycetes*, p. 147. 1892), re-transferred it to *Lasiosphaeria*, is not apparent, since their own characterization of that genus—"sporidia hyaline or subhyaline, cylindrical or vermiform"—does not in the least apply to the specimen of the fungus in question, distributed by them (*N. Amer. Fung.*, No. 1342).

This fungus, so closely resembling *Herpotrichia nigra*, appears to be fairly common throughout the mountainous regions of the western and northwestern states. Both fungi are found in the same localities; but whereas the *Herpotrichia* occurs in this country on *Abies* and *Picea* exclusively, so far as is at present known, the *Neopectia* appears to be confined to the genus *Pinus*. My own specimens were collected in September, 1903.

on *Pinus Murrayana*, in the neighborhood of Pacific Creek, Wyoming. The specimen distributed by Ellis & Everhart is labelled merely "on *Pinus contorta*. Rocky Mts., Cal." Two specimens received from Mr. C. L. Shear are from Oregon and Idaho respectively: one is on *Pinus contorta*, the other is marked "on living *Pinus*." The dates of collection range from July to September, and all of the specimens exhibit fully mature spores.

The following detailed description of the fungus is drawn from the Wyoming specimens:

Neopeckia Coulteri (Pk.) Sacc. Perithecia spherical, 0.32 to 0.5 mm. diameter, immersed, except for the slightly prominent, flattened ostiola, in a dark brown, felt-like subiculum, 0.4 to 0.53 mm. thick. Asci cylindrical, 150 to 185 μ by 15 to 18 μ . Paraphyses filiform, fugacious. Spores obliquely uniseriate in the asci, blunt-elliptical, at first pale brownish, later dark-brown, 1-septate, constricted at the septum, 20 to 29 μ by 9.5 to 10.2 μ .

Habitat. On living leaves and twigs of *Pinus Murrayana* and *Pinus contorta* (Wyoming, California, Oregon and Idaho).

Synonyms. *Sphaeria Coulteri* Peck (1872); *Lasiosphaeria acicola* Cooke (1880); *Amphisphaeria? acicola* (Cke.) Sacc. (1882); *Enchnosphaeria Coulteri* (Pk.) Sacc. (1883); *Lasiosphaeria Coulteri* (Pk.) Ell. & Ev. (1892).

Exsiccati. Ellis & Everhart, N. A. Fungi, No. 1342.

The damage caused by these two fungi is, according to my limited observation, inconsiderable. In Europe *Herpotrichia nigra* is said to attack seedling conifers, and even to kill them by completely covering them with matted mycelium. In other cases the seedlings, bent over under the weight of snow, become fastened to the ground by the mycelium and only recover with difficulty. In this country, however, the only specimens which I have seen, whether of *Herpotrichia* or *Neopeckia*, were on trees of larger growth and the injury was confined to not more than one foot of the ends of branches a few feet from the ground. These portions were killed.

I have considered these two fungi at such length, partly because of the damage which they are undoubtedly capable of causing to conifers either in the seed-bed or later, but chiefly because, notwithstanding their common occurrence, one of them has heretofore been reported only once from the United States and neither has received the attention it deserves from American mycologists. The past history of both, too, appears to have been so confused owing, in a measure, to their extraordinary similarity in external appearance and in structure, that I have thought it advisable to straighten out the confusion as best I might.

COLORADO SCHOOL OF FORESTRY

COLORADO SPRINGS

EXPLANATION OF PLATE XII

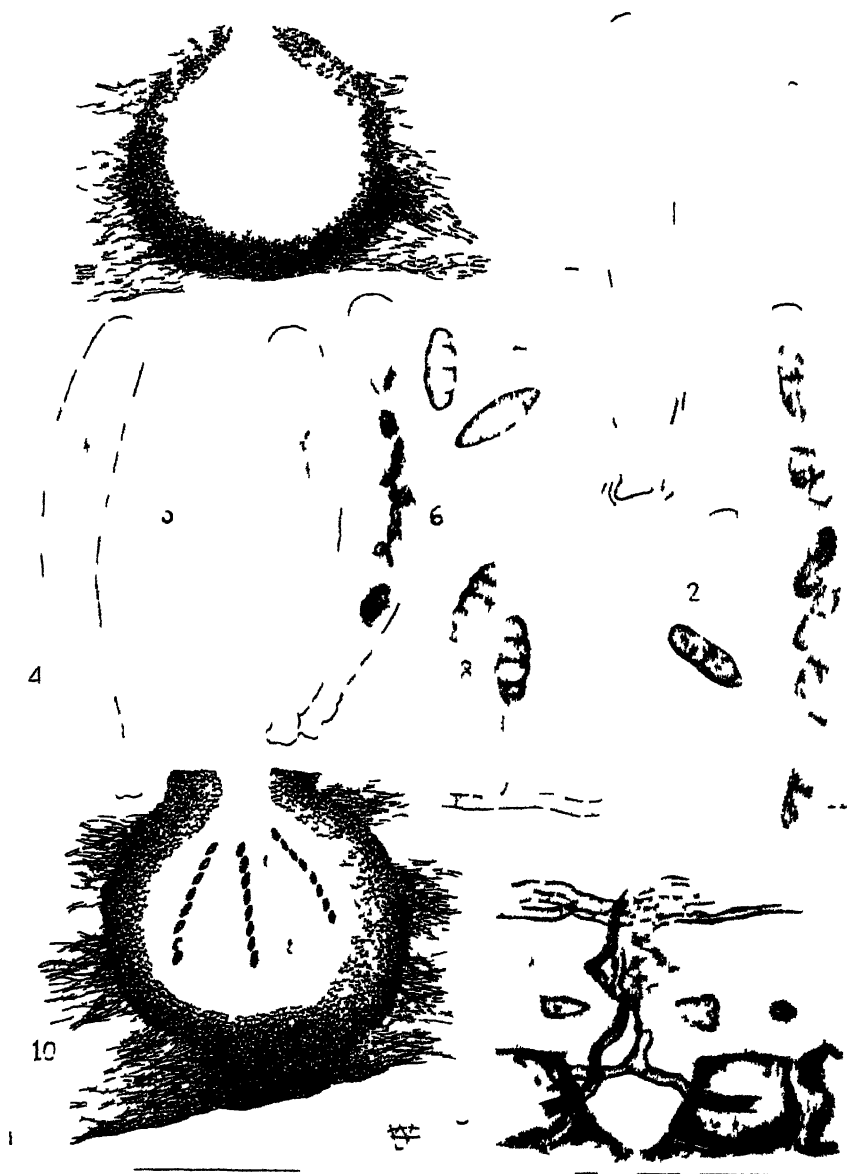
- FIGS. 1-3. Twigs of *Pinus Murrayana* infested with *Neopeckia Coulteri*. $\times \frac{1}{3}$.
FIG. 4. Branch of *Abies lasiocarpa* infested with *Herpotrichia nigra*. $\times \frac{1}{3}$.

EXPLANATION OF PLATE XIII

- FIG. 1. *Herpotrichia nigra*. Section of perithecium. $\times 100$.
FIG. 2. The same. Paraphyses and ascus with immature spores $\times 475$.
FIG. 3. The same. Two immature spores and one mature. $\times 475$. (Figs. 2 and 3 from specimen in A. & S. Fung. Bav., No. 70.)
FIG. 4. The same. Ascus with immature spores. $\times 475$.
FIG. 5. The same. One immature spore and two mature. $\times 475$. (Figs. 4 and 5 from specimen on *Picea*.)
FIG. 6. The same. Two asci with spores $\times 475$.
FIG. 7. The same. One immature spore and two mature. $\times 475$. (Figs. 6 and 7 from specimen on *Abies*.)
FIG. 8. The same. Hypha and conidia from mycelium on *Picea*. $\times 475$.
FIG. 9. The same. Mycelium penetrating and filling a stoma. $\times 475$.
FIG. 10. *Neopeckia Coulteri*. Section of perithecium. $\times 100$.
FIG. 11. The same. Ascus with nearly mature spores. $\times 475$.
FIG. 12. The same. One immature spore and one mature $\times 475$.



HERPOTRICHIA AND NEOPECKIA ON CONIFERS



HERPOTRICHIA AND NEOPECTIA ON CONIFERS

THE BLACK ROTS OF THE SWEET POTATO¹

J J TAUBENHAUS

WITH PLATES XIV, XV and XVI

THE BLACK ROT. *Sphaeronema fimbriatum* (E.&H.) Sac.

The term black rot of the sweet potato as usually understood by plant pathologists is that disease which is induced by the fungus *Sphaeronema fimbriatum* (E. & H.) Sacc. We owe our past knowledge of this disease to Halsted² who in 1890 was first to give us an account of the diseases of the sweet potato. However, Halsted's account of the black rot is incomplete. The disease is characterized by dark greenish circular spots (plate XIV, fig. 3) varying in size from $\frac{1}{2}$ to 2 inches in diameter. These roundish spots are more often met with in infected sweet potatoes in the store house. When the roots are injured through rough handling in cultivation or by rodents, the spots lose their circular outline but follow the line of injury. When the infected root is uninjured, the spots are smooth and appear as if burned in with a metal dye. The pycnidia do not appear for a considerable time after infection, especially when the infected roots are kept under dry conditions. They finally develop on the epidermis (plate XIV, fig. 4) in the center of the spot. None are formed within the infected tissue of the root.

Three years of observation on the black rot in Delaware have shown that the disease does not produce decay of the entire root, as is usually believed, but is confined to the cambium layer. In cases of black rot where the entire root decays, it is due to secondary infections of one or two species of *Fusaria* or of *Trichoderma koningi* Oud. Cultures of the interior tissue of such infected roots always gave a pure growth of the above fungi but not of the *Sphaeronema*. If no secondary infection sets in, sweet potato roots attacked by the *Sphaeronema* alone can remain entire the whole of their life. The spots gradually spreading over the surface of the root but leaving the interior unharmed. In cases of deep injury or of transverse cuts, the fungus enters the center, then gradually invades the entire root. The cut surface is covered with a web of ashy-colored

¹Phytopathological Society at the Cleveland meet-

of the sweet potato. N. J. Agr. Exp. Sta.

mycelium of the *Sphaeronema* fungus, soon to be followed by the thickly set pycnidia which now cover the entire area. *Sphaeronema fimbriatum* imparts a bitter taste to the affected spot. When such root is cooked for eating purposes the bitter taste permeates the whole root, but if the infected area is first cut out, the edible quality of the remainder of the root is unimpaired.

Our studies on the morphology of *Sphaeronema fimbriatum* bear out in part those of Halsted and Fairchild.³ Old mycelium is darkish gray, with rather close septa, and usually filled with oil globules when grown on media rich in sugar. The young mycelium is hyaline but becomes grayish with age. The hyphae young or old are capable of breaking up into as many cells as there are septa and each cell germinates like a spore (plate XV, figs. 5 to 8, 10, 12 to 14, 26, 27, 28). Another stage of spore formation corresponds in part to Thielavia, namely, the spores are borne within the sheath of a terminal cell, and these are pushed out from within (plate XV, figs. 15 to 17). There is another spore stage consisting of olive-brown conidia (plate XV, figs. 13, 17 to 22, 28). These are thick-walled, and are borne singly, by twos, or in chains. These brown conidia apparently serve as resting spores, since it takes them a much longer time to germinate. This type of spore is often found in the interior of the affected tissue, in the cells immediately below the epidermis (plate XIV, fig. 4). A last stage is that of pycnosporos, which are borne in long-necked pycnidia (plate XIV, fig. 4). The spores are globular, minute, oozing out in a gelatinous mass, and stick at the open end of the long neck of the pycnidium. Any of these spores germinate in water or in any nutritive fluid (plate XV, figs. 1 to 9, 22). No perfect stage has as yet been found and no spore stages other than those above mentioned have been observed, in pure cultures or on the host, to be connected with the *Sphaeronema fimbriatum*.

The pathogenicity of *Sphaeronema fimbriatum* can readily be established by placing the sweet potato roots or potted plants in a moist chamber and spraying them with a suspension of spores of any of the stages of the fungus, or by inserting bits of pure culture mycelium into the tissue of the host. The disease usually develops within two to three weeks after infection, producing the typical black rot symptoms (plate XIV, figs. 2 and 3). moist atmosphere, either in the field or in the store house, ^{for} conditions for infection. Occasionally, in a lot of sweet the roots will remain entirely immune to either artificial indicating, therefore, the possibility of resistant st that the smallest roots are the most resistant. why sweet potato growers prefer small root

³ Halsted, B. D. and Fairchild, D. G. *Swa*
1-11. 1891.

The spread of the disease in the field is no doubt due to infected roots (seeds) and infected manure. It is usually a common practice among growers to dump all infected roots on the manure pile. The cultivator, as well as field rodents, also help to spread the disease from hill to hill. In storage the disease is introduced on infected roots and then spread by means of mites and the red spider. The two latter when transferred from diseased to healthy roots will communicate the disease to the healthy ones. A pure culture of the fungus can also be obtained when these insects are taken from infected roots and allowed to crawl over a poured plate of culture media (plate XIV, fig. 5).

CHARCOAL ROT OF THE SWEET POTATO. *Sclerotium bataticola* n. sp.

Historical. In describing the morphology of *Sphaeronema fimbriatum* Halsted⁴ notes a fourth or sclerotium stage of that fungus. To quote Halsted, "A fourth form of the black rot is sometimes found in which the substance of the potato becomes filled with minute, black, irregular masses. The root thus affected takes on a color that looks like charcoal. A highly magnified view of a small portion of the fungus is seen to consist of black nodules with brown threads running from one to another.

In writing again on the sweet potato black rot, a year later, Halsted and Fairchild⁵ seem to be undecided as to whether the sclerotium fungus above mentioned was or was not a stage of the *Sphaeronema fimbriatum*, for they say: "Although not certainly connected with the species of fungus causing the black rot, there have been found, often in badly diseased specimens, immense numbers of globular sclerotia differing in structure from those of many other species, but surrounded by and evidently made up of hyphae identical with these of this species. These sclerotia were found in all stages of formation, and in the last stages in such abundance as to entirely fill the tissue of the diseased potato, causing it to become gray and finally charcoal-black."

Later workers on sweet potato diseases all quote Halsted verbatim, and apparently all accept his statement that the sclerotium fungus is a stage of *Sphaeronema fimbriatum*.

Burnette⁶ in discussing the black rot, *Ceratocystis fimbriata*, states among other things that: "After a time the entire root becomes filled with a dark fungus growth, which characteristic gives it the name of black rot. Still further along in its course of development a stage is reached in which the

⁴ Loc. cit., pp. 11-18.

⁵ Loc. cit., pp. 1-11.

⁶ Burnette, F. H. Sweet potatoes. La. Agr. Exp. Sta. Bul. 30 (second series), p. 1098. 1894

whole inner substance assumes a charcoal-like condition. This is called the sclerotial stage, and seems to be the most common condition in which we find potatoes affected by the disease here."

Townsend⁷ in his discussion of the black rot fungus, accepts Halsted's⁸ view, as he says: "The threads of the fungus enlarge and turn dark in certain places, forming nodules. Although these bodies are not strictly spores, they perform the same functions as spores."

Wilcox⁹ in his description of the black rot, *Ceratocystis fimbriata*, also states: "In addition to these methods of reproduction (conidia and pycnidia, the fungus produces hard dark-colored roundish bodies inside the root known as sclerotia. These are simply compact masses of vegetative filaments of the fungus, but each one of the masses is capable of developing the other stages and spores of the fungus."

Finally, in a recent review of the black rot of the sweet potato, Duggar¹⁰ supports the view of Halsted, for he adds: "When the mycelium has developed to a considerable extent in the root, sclerotia of large size appear. It is believed that these sclerotia may be properly a phase in the life history of this species, and that they may also be important in the perpetuation or spread of the fungus."

There is no doubt that all the authors which I have quoted had in mind Halsted's supposed sclerotium stage of *Sphaeronema fimbriatum*, since all, with the exception of Duggar, reproduced the same figures as Halsted¹¹ gave in his bulletin on the diseases of the sweet potato. It is surprising that twenty-two years should have elapsed since Halsted gave us the first knowledge of the sweet potato diseases, and that no subsequent worker should have tried to determine definitely whether or not the sclerotium fungus here in question is a stage of *Sphaeronema fimbriatum*. Our own investigations have shown conclusively that it is not, but that it is distinct and in no way related to the *Sphaeronema*. I have already shown that the black rot only produces spots on the surface of the root which when once seen cannot be mistaken. This disease does not penetrate the root much further than the cambium layer. The sclerotium fungus, on the other hand, does not seem to produce surface spots and it invades the entire contents of the root, turning the substance to a charcoal mass (plate XIV, fig. 10). I propose, therefore, the name of "charcoal rot" for the sclerotium disease.

⁷ Townsend, C. O. Some diseases of the sweet potato and how to treat them. Md. Agr. Exp. Sta. Bul. 60. 1899.

⁸ Loc. cit.

⁹ Wilcox, E. M. Diseases of sweet potatoes in Alabama. Ala. Agr. Exp. Sta. Bul. 135: 6. 1906.

¹⁰ Duggar, B. M. Fungous diseases of plants, p. 349. 1909.

¹¹ Loc. cit.

With the exception of drying and slight shrinkage, there are no external symptoms to distinguish this disease. It can only be recognized when the roots have been completely invaded by the fungus. Such roots become light and dry and can be readily broken in two. The interior tissue is found to be entirely black and charcoal-like. This blackening is due to the formation within the host of numerous minute sclerotia (plate XIV, fig. 11). A pure culture of the fungus can be readily obtained by aseptically breaking an infected root and picking out bits of tissue with a sterile needle and dropping them into poured plates of nutrient agar. The fungus grows well on media rich in sugar, although it develops equally as well on a variety of other media. With the exception of the sclerotium stage, no other fruiting body of any kind has been observed, either in pure culture or on the host.

Halsted¹² figures a sclerotium bearing dark, roundish spores on slender stalks, resembling the brown olive-shaped spores of *Sphaeronema fimbriatum*.

Such spore-bearing sclerotia have often been found by us to be connected with *Sphaeronema fimbriatum* (plate XV, fig. 25). However, these bodies are not really sclerotia, but merely immature pycnidia, since they can be readily crushed under a cover glass, whereas the sclerotia of the fungus here in question are hard and resist crushing. Halsted's figure must be hypothetical or else that of a young pycnidium of *Sphaeronema*.

Pathogenicity. The most severe test as to whether this sclerotium fungus is or is not a stage of *Sphaeronema* is its pathogenicity. When bits of pure cultures of the sclerotium fungus are inserted into healthy sweet potato roots the typical charcoal disease is induced within three to eight weeks after infection. The fungus can then be reisolated from the artificially infected roots and the disease produced again at will, and each time only the sclerotium fungus is involved. On the other hand, when a pure culture of the *Sphaeronema* is inoculated into healthy sweet potato roots, the typical black rot disease is induced at will; and at no time has the charcoal disease or the sclerotium mass appeared. This conclusively proves that the charcoal disease, and the sclerotium fungus which induces it, is distinct from the black rot which is induced by the fungus *Sphaeronema fimbriatum*.

Life history. Diseased roots kept dry for one year will readily yield a pure culture of the fungus, thus showing that these diseased roots carry the fungus from year to year. There seems no doubt that the fungus is kept alive and spreads from the store house to the field, and vice versa, through the manure, and possibly with infected roots.

Taxonomy. In identifying sclerotium-producing fungi, one is often at sea, on account of the meagre descriptions of published species. The writer has carefully examined Schweinitz's collection of *Sclerotium* at

¹² Loc. cit.

the Academy of Natural Sciences in Philadelphia. No species there were found to agree with the one here in question. Moreover, our present species could not be found to correspond with any of the species described and recorded by Saccardo.¹³ Several attempts have been made to germinate the sclerotia with the hope of producing a perfect stage. However, it was found that in every attempt the sclerotia would merely produce new sclerotia. Therefore, until a perfect stage or some other spore form is found, the name *Sclerotium bataticola* n. sp. is proposed, with the following description:

***Sclerotium bataticola* n. sp**

Sclerotia jet black, very minute; exterior smooth, made up of anastomosed black hyphae; interior light to dark brown, made up of free, thick-walled, cortical, hyphal cells; sclerotia vary much in shape, spherical, oval, oblong, elliptical, curved or even forked, varying in size from $25 \times 22.4 \mu$ to $152 \times 32 \mu$, abundant throughout the entire root of the host.

Parasitic on living roots of sweet potato, *Ipomoea batata*.

JAVA BLACK ROT. *Lasiodiplodia tubericola* E. & E.

This is a third form of sweet potato black rot.

Historical. The only account we have of the fungus is a short note by Clendenin.¹⁴ The fungus was first found on some sweet potatoes that were brought to the Louisiana Station from Java in the spring of 1894. The potatoes appeared sound, but failed to grow when planted. Upon examination the roots were found to be rotted. The fungus which caused the rot was sent to Ellis, who identified it as a new genus and gave it the name of *Lasiodiplodia tubericola*. Sweet potatoes brought from Java in the spring of 1895 were found to be affected with the same fungus when they were received at Baton Rouge. This seems to indicate that the fungus was introduced from Java to the United States. We do not know how it was introduced into Delaware, where it was first noticed by the writer in 1910 on stored roots.

Symptoms. Sweet potatoes affected by this fungus show dark shrivelled patches, over which are scattered numerous pycnidia. These emit either mature one-septate dark spores of the *Lasiodiplodia* type, heaped together, or white strings which are made up of hyaline *Macrophoma* spores, or both. In making longitudinal sections through different stages of affected roots, it will be found that the fungus attacks the interior tissue beginning at a point and gradually invading the whole of the interior of the root (plate

¹³ *Sylloge Fungorum* 14: 1139-1174; 18: 690-691.

¹⁴ Clendenin, Ida. *Lasiodiplodia* E. & E. *Bot. Gaz.* 21: 92. 1896.

XIV, fig. 7). The infected tissue is jet black, somewhat resembling the charcoal disease. Infected roots dry and shrivel and become brittle. The name Java black rot is proposed for this disease in order to distinguish it from the other two black rots, and because diseased sweet potatoes suffering from this disease were first introduced from Java.

Pathogenicity. No infection experiments have ever been recorded before with this fungus on the sweet potato. In our investigations we find it to be an active parasite, since the disease can be induced at will either by placing healthy roots in a moist chamber and spraying with a suspension of pycnosporos of the *Macrophoma* or *Lasiodiplodia* types, or by inserting bits of mycelium from a pure culture of the fungus into the healthy root. In either case complete rotting of the root is effected in four to eight weeks, some roots being more susceptible than others. It seems that the fungus works by means of an enzyme, for in a longitudinal section of a newly infected root two zones can be observed (plate XIV, fig. 7), one, a dark patch, is occupied by the fungus, and the other, a brown zone, precedes the dark patch and is devoid of mycelium. The pycnidia are born singly or in groups under the epidermis (plate XIV, fig. 8), and the latter is ruptured at an early stage. They are also formed throughout the interior tissue of the affected root, and it seems that in this case the spores can only escape when the infected roots break up and disintegrate. The pycnidia when borne free may or may not possess hair-like bristles at the openings of the necks. Also, they may or may not have paraphyses. It was only because of the presence of paraphyses in the pycnidia that Ellis created the genus *Lasiodiplodia*. More work is now in progress to determine the relationship of this fungus with other *Lasiodiplodias* and with species of the genus *Diplodia*. A more extended description of the three black rots will soon be published in bulletin form.

Type material of *Sclerotium bataticola* has been deposited in the herbaria of the Delaware Agricultural Experiment Station, the Departments of Plant Pathology at Cornell University and the University of Wisconsin, the New York Botanical Garden and the National Museum at Washington, D. C.

DELAWARE AGRICULTURAL EXPERIMENT STATION

NEWARK, DELAWARE

EXPLANATION OF PLATE XIV

Figures 1 to 5, *Sphaeronema fimbriatum*, figures 6 to 9, *Lasiodiplodia tubericola*; figures 10 and 11, *Sclerotium bataticola*

FIG. 1. Healthy sweet potato plant (check).

FIG. 2. Sweet potato plant artificially infected with the black rot organism.

FIG. 3. Black rot of sweet potato as it appears naturally and as a result of artificial infection

FIG. 4. Photomicrograph of cross-section of an infected sweet potato, showing a pycnidium of the black rot fungus.

FIG. 5. Poured plate of agar with mite taken directly from a root infected with black rot and placed at center. Notice colony of *Sphaeronema fimbriatum* in center of plate, and two rows of bacterial colonies marking the tracks followed by the mite

FIG. 6. Surface view of a sweet potato showing early infection of the java black rot. Notice in the central portion of the spot the white strings of *Macrophoma* spores and the black powder of one-septate *Lasiodiplodia* spores oozing out from the pycnidia

FIG. 7. Longitudinal section of potato shown in figure 6.

FIG. 8. Photomicrograph of a cross-section of a sweet potato showing cluster of pycnidia without bustles, formed immediately below the epidermis. *

FIG. 9. Photomicrograph of cross-section of sweet potato, showing pycnidia with long necks and bristles, formed immediately below and breaking through the epidermis.

FIG. 10. Cross-section of healthy and diseased roots infected with *Sclerotium bataticola*.

FIG. 11. Photomicrograph of cross-section of sweet potato to show presence of sclerotia in the host.

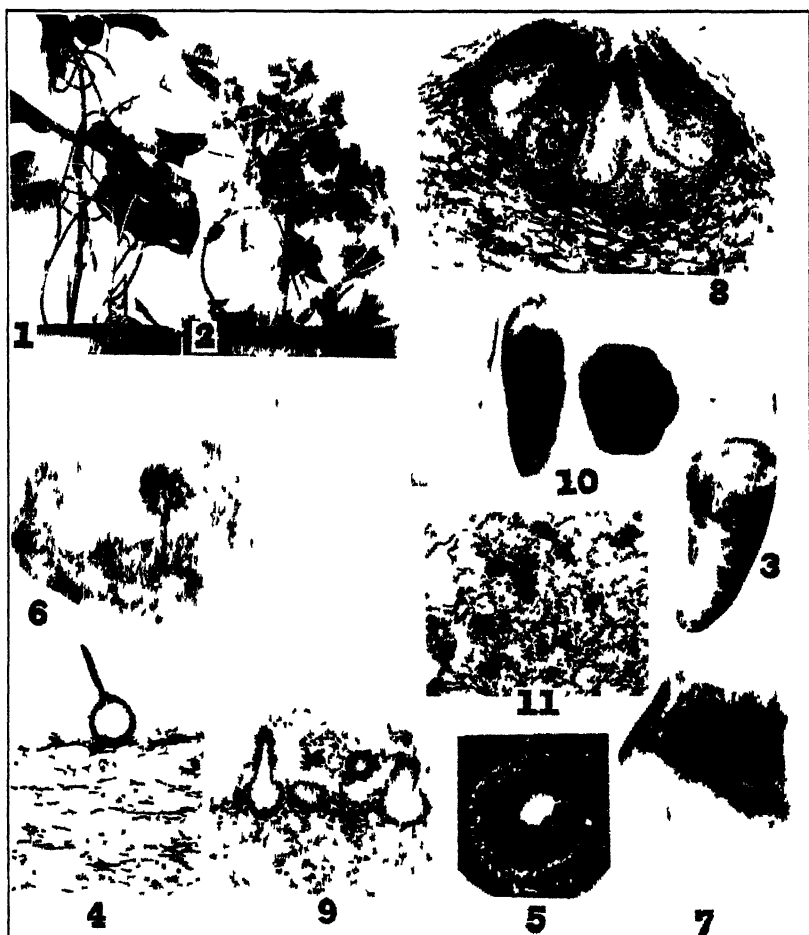


PLATE XIV. BLACK ROTS OF SWEET POTATOS

EXPLANATION OF PLATE XV

Figures 1 to 28, *Sphaeronema fimbriatum*; figures 29 to 42, *Lasiodiplodia tubericola*.

FIGS. 1, 9, and 22. Stages in the germination of the brown olive-shaped thick walled conidia.

FIGS. 5 to 8, 10, 27 and 28. Different stages in the germination of the hyaline conidia.

FIGS. 2 to 4 and 11. Different stages in the germination of the pycnospores.

FIGS. 13, 17 to 22 and 29. Different stages in the formation of the brown conidia.

FIGS. 12, 13, 14 and 26. Hyphae breaking up into spores.

FIGS. 15 to 17. Thielavia-like spore formation.

FIG. 25. Young pycnidium resembling a sclerotium.

FIGS. 29 to 37. Different stages of germination of the *Lasiodiplodia* spores.

FIGS. 32 and 36. Striated spore cover. The striations are better visible when the spore germinates.

FIGS. 38 to 42. Different stages of germination of the *Macrophoma* spores of *L. tubericola*.

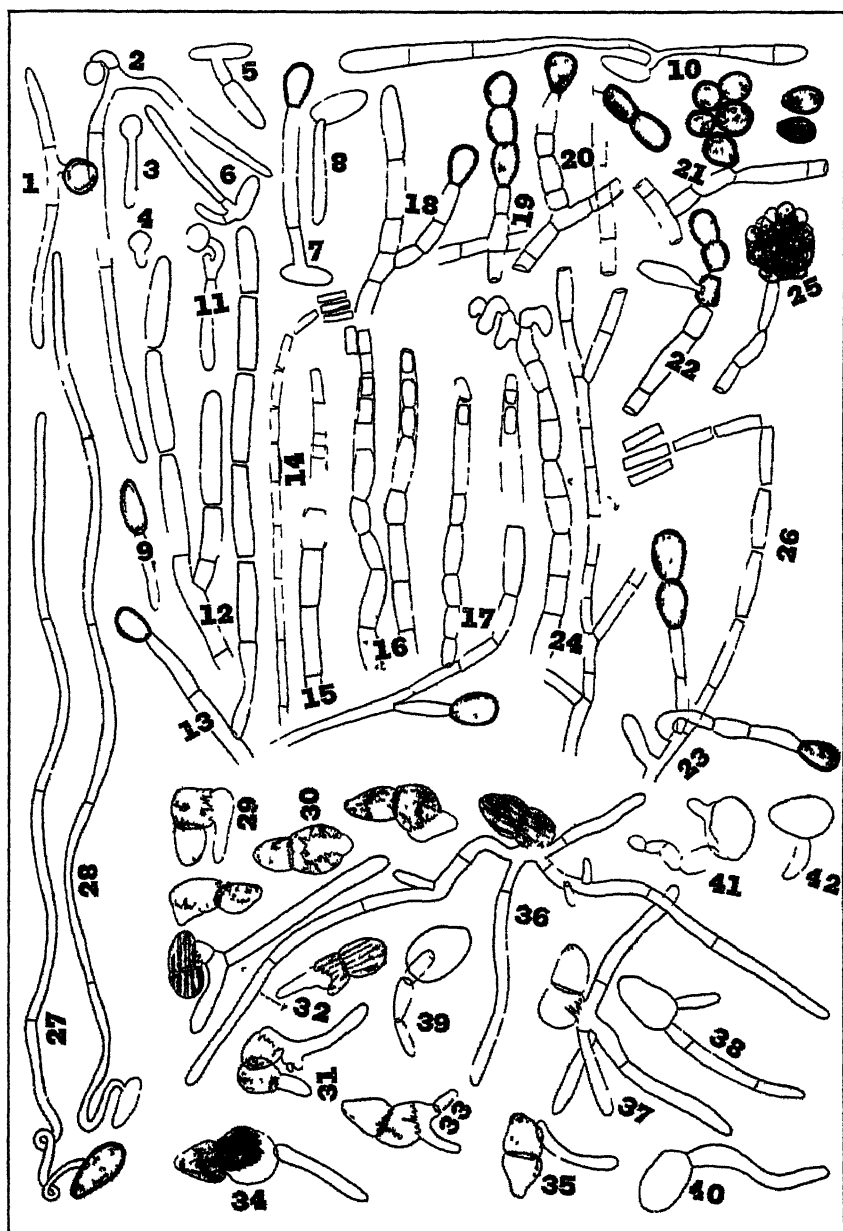


PLATE XV. BLACK ROTS OF SWEET POTATOES

EXPLANATION OF PLATE XVI

Figures 43 to 53, *Lasiodyplodia tubericola* continued; figures 53 to 59, *Sclerotium bataticola*.

FIGS. 47 to 50. Variation of size in the *Lasiodyplodia* spores.

FIG. 43. Attachment of spores and paraphyses to the inner wall of the pycnidium

FIG. 44. A single paraphysis

FIG. 45. Stages of formation of pycnospores.

FIG. 46. Crush mount showing the fungus *Sphaeronema fimbriatum* to be inter and intracellular. The brown olive-shaped conidia are also born within the host cells.

FIGS. 53 to 59. Different stages in the sclerotium formation

NOTE—All drawings are made with the camera lucida.

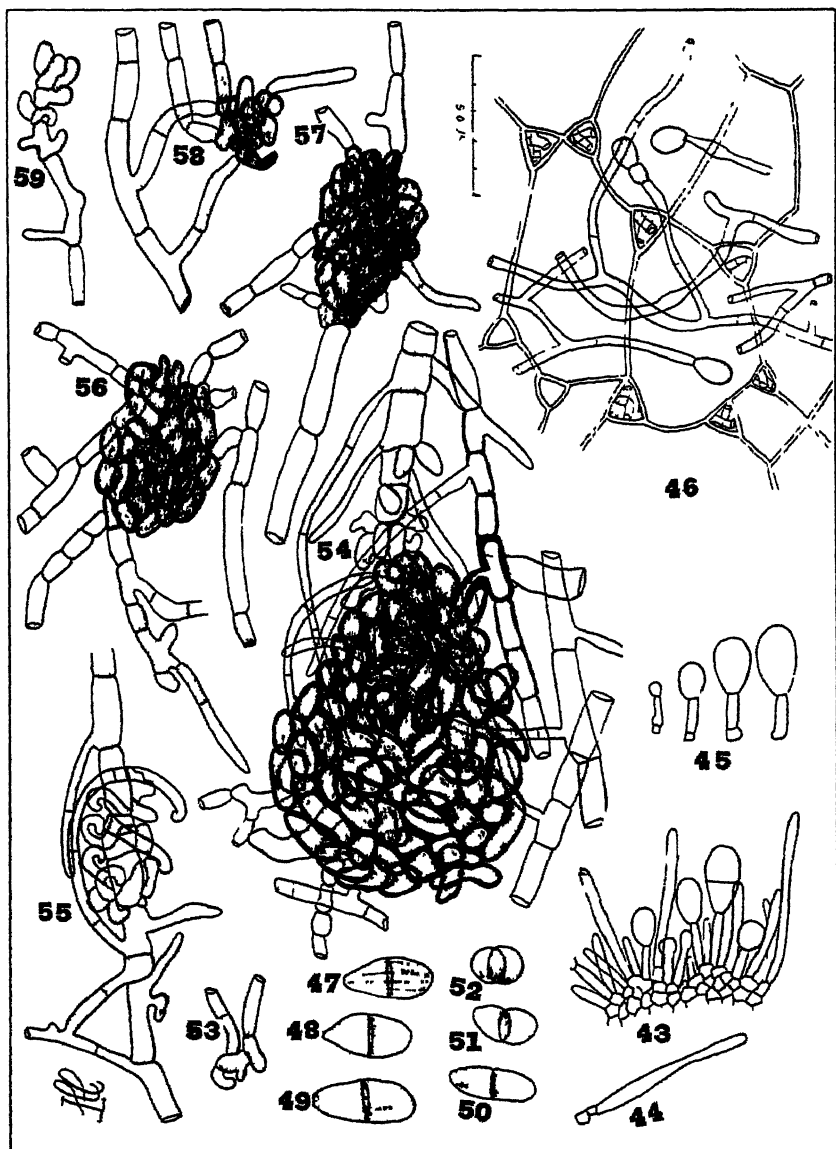


PLATE XVI. BLACK ROT OF SWEET POTATOES

NOTES ON CRONARTIUM COLEOSPORIOIDES ARTHUR AND CRONARTIUM FILAMENTOSUM

E. P. MEINECKE

In PHYTOPATHOLOGY 2: 176, August, 1912, Dr. George G. Hedgcock reported successful inoculation of two species of *Castilleia* with aeciospores of *Peridermium filamentosum* Peck and proposed the name *Cronartium filamentosum* (Peck) Hedgcock comb. nov. for the resulting Cronartium. Dr. Hedgcock proposed the new name on account of my successful inoculation of *Castilleia miniata* with *Peridermium stalactiforme* Arthur and Kern, which established the relationship of the latter species of *Peridermium* with *Cronartium coleosporioides* (Dietel and Holway) Arthur, and for the further reason that Dr. Arthur has considered the two forms of *Peridermium* to be morphologically different and has raised them to specific rank, thus rendering the identity of the two species of *Cronartium* uncertain, although they appear to be morphologically identical.

On September 16, 1911, I had found *Cronartium coleosporioides* very plentiful on *Castilleia miniata* in the immediate neighborhood of aecia of *Peridermium stalactiforme* in the Lassen national forest, California.¹ This fact, together with Dr. Hedgcock's early conjecture (July, 1911) that *Peridermium filamentosum* formed its *Cronartium* on *Castilleia*, led me to try inoculation with *Peridermium stalactiforme*. *Pinus contorta* in the neighborhood of Fort Klamath, Oregon was found to be richly infected with this *Peridermium*, and at the end of May, 1912, when the aecia were just opening and some of them discharging spores, specimens were collected for use in inoculation. In the same locality, and on the same day, squares of sod each containing about six to eight young plants of *Castilleia miniata* were cut out. These squares were immediately packed in the field and carefully guarded from any possible contamination from the *Peridermium* material. On the following day all the material was taken to Odessa, Oregon, 25 miles away, where no *Peridermium stalactiforme* is found. At Odessa one of the squares was richly dusted with aeciospores of *Peridermium stalactiforme*. The inoculated and the uninoculated material was then transferred to the botanical garden of the University of California at Berkeley and kept in separate houses.

Inspection on June 18 showed the *Cronartium* stage plentifully developed

¹ *Mycologia* 4: 142. May 1912.

on the older leaves of the inoculated *Castilleja* plants. There were some uredospores present. The teliospores showed signs of germination. On June 20 many rather larger sporidia had been formed. The check material was free from *Cronartium* and remained healthy,

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY

UNITED STATES DEPARTMENT OF AGRICULTURE

SAN FRANCISCO, CALIFORNIA

A BACTERIAL ROT OF CUCUMBERS

O. F. BURGER

The cucumber crop of Florida has been seriously injured during the last two years by a bacterial disease of the leaves and fruit. Brown spots which may fuse into large brown patches appear on the leaves. On the fruit watery spots with brown centers are seen, and later the cucumbers become soft and translucent throughout. The first signs of infection on the leaves are watery spots. In the early morning a drop of bacterial ooze is to be found on the under side of the leaf on the water-soaked spot. Later in the day the ooze dries, leaving a white residue. The spots turn brown, and when old drop out of the leaf.

The first spots on the fruit are from 1 to 2 mm. across, and have, as has been stated, a water-soaked appearance. Each has a darker center formed of dead epidermal cells, and appearing as if some insect had punctured the fruit there. The spot does not spread laterally on the surface, but the sub-epidermal tissue turns brown. The infection reaches the vascular system, and then spreads quickly, softening and browning the tissues as it advances. Finally the whole cucumber is reduced to a soft watery mass. The cucumber grower pays little attention to small spots on the fruit, and thus diseased cucumbers are often packed with good ones, with the result that on arrival at the market the baskets may be "leaking." It takes from three to four days for the shipment to reach the market, and in this time much of the infected fruit becomes soft.

Cultures were made from a young spot by cutting small pieces from under the epidermis with a sterile knife and dropping them into tubes of beef bouillon. In twenty four hours the bouillon was cloudy with a bacterial growth. The culture was brushed on a cucumber with a camel's hair brush, and the fruit was then wrapped with paraffined paper. The characteristic spotting appeared. The organism was isolated from this inoculated fruit, and pure cultures transferred to tubes of beef bouillon. These cultures were then brushed on cucumber leaves, and the characteristic leaf spotting appeared. Infected cucumber leaves were brought in from the field and pinned to healthy leaves; the characteristic spots appeared on the healthy leaves. No infection occurred in check plants.

The cucumber growers complained in some cases that the vines were not setting fruit. The ovaries of the flowers were yellowing and drying up. Pure cultures of the bacterium were inoculated into healthy female flowers.

The ovaries after the inoculation did not develop any further, but turned yellow, blackened and dried up.

Microscopical examinations of the spots on the leaves and fruit always showed abundance of motile bacteria. Portions of diseased leaves and fruit were killed in chrom-acetic acid (medium strength), embedded in paraffin, sectioned and stained with iron-alum hæmatoxylin. In all cases bacteria were found to be present in the tissue.

The bacteria grown in standard agar (reaction + 1.5 %) at 30°C. and stained with gentian violet, showed as short rods 1.5 to 2 microns long and 1 micron wide, the majority being 2 microns long. Stained by Hugh Williams' method they showed three to six polar flagella, the majority having only three. Ribbets' method showed the presence of a capsule. The bacteria are not stained by Gram's method. Spores have not been found.

Stroke cultures on regular beef agar (reaction + 1.5 %) are scanty, filiform, flat, glistening, verrucose, opalescent, and slimy. In agar stab cultures, growth is best at top, villous in line of puncture. Gelatin stab cultures show best growth at top, villous in line of puncture. Gelatin is not liquified. A membrane is formed on nutrient broth; strong cloudiness; compact sediment. Milk coagulates slowly; extrusion of the whey began in seven days. Agar colonies are round to ameboid, smooth, convex, and amorphous. There was no gas formed in fermentation tubes; growth occurred in the closed arm. To test tubes containing 10 cc. of milk 1 cc. of methylene blue was added; these were bleached in four days by the organism. In beef bouillon with 2 per cent glycerine or 2 per cent saccharose, there is fluorescence. No indol is produced. Nitrates were not reduced. Starch was digested.

The cultural characteristics of this *Pseudomonas* are being further investigated together with field control methods.

FLORIDA AGRICULTURAL EXPERIMENT STATION
GAINESVILLE, FLORIDA

A BOTRYTIS DISEASE OF DAHLIAS¹

MEL T. COOK AND C. A. SCHWARZ

WITH PLATE XVII

During the past year our attention was called to a root rot of dahlia in storage. It was reported as quite severe by one grower, others considered it of little or no importance, while many had not been troubled with it and did not know anything about it. It was most severe on the Sylvia, a decorative variety, and on Kriemhilde, a cactus variety. In only one case was it reported as giving trouble in the field, and the writer did not see that case. This single field record was for the Sampson variety.

The diseased roots have a watery appearance, the interior is soft and wet, becoming yellow, brownish and finally black. The determination of the cause of this disease was complicated by the presence of a number of other organisms which contributed to the rot when it was once started by the primary factor. This primary factor was finally found to be a grayish or brownish *Botrytis*.

The disease appeared to be most severe under warm, moist conditions, combined with poor ventilation. However, roots buried in pits for the winter with no ventilation and considerable moisture were in perfect condition. Many inoculation experiments indicate that the organism is unable to gain entrance to the host except through wounds. Pure cultures of the organism applied to the clean, sound surface of roots failed to produce the rot, while inoculation from the same cultures on cut surfaces produced the disease very readily.

The organism is a typical *Botrytis*, growing well on almost any medium and producing an abundance of conidia and, later, an abundance of sclerotia which are variable in size some of them attaining as much as 11 mm. in diameter. The sclerotia are less abundant on the roots and much smaller. This organism has been under observation for the past year and has been grown in a number of different media, but thus far it has not produced a perfect stage.

The mycelium is septate and branched (fig. 1), the conidiophores are of the *B. cinerea* type (fig. 2) and the spores are elongated, measuring from 11.25 to 15 microns in length, averaging 13.43 microns. In germination

¹ Read before the American Phytopathological Society at Cleveland, Ohio, January 2, 1913.

the spores become spherical and send out one, two or three germ tubes (fig. 4) which soon become septate and branched and form peculiar structures (fig. 5) similar to, and possibly the same as, the organs of attachment described by Smith (2). However, a careful study of these organs in hanging drop cultures indicated that they were in reality the incipient sclerotia (figs. 6 to 11). It was possible to trace a complete series, beginning with the formation of these structures and ending with well defined sclerotia. The first stage in their development is the formation of many irregular, short branches, many septa, and an irregular, clubby or knotty appearance. It was also apparent that a sclerotium might be formed from a single mycelium (fig. 9), or that a considerable number might be involved (figs. 10 and 11).

The study of the germination of the spores in drop cultures also showed a tendency for the mycelial branches to unite, whether they came from the same or different spores (figs. 12 a, b; 13 a to i). In fact it appeared very evident that when two young mycelial tubes approached within a short distance of each other, they formed a direct union or joined, by means of short mycelial growths. This peculiar attractive force also frequently resulted in the formation of two short lateral tubes from a single mycelium uniting with the tip of an approaching mycelium. This union of mycelia has been observed by Ward (4) who called attention to its similarity to conjugation in various other fungi, and also to the fact that the influence seemed to be the same as that resulting from the conjugation of zoospores among the thallophytes and of sex cells in the archegoniates. He attributed this conjugation to an enzyme activity. Smith (2) figures a union of mycelia, but makes no comment on it; he also figures branching structures similar to those described in this paper but does not show any relationship to sclerotial formation. Price (1) also figures organs of attachment and his figure 8 indicates a possible union of mycelial growths.

Spore plantings were made at definite points in petri dishes and allowed to grow until the mycelial growths came in contact, when it was readily seen that the sclerotia were much more abundant along the intersecting lines than at other points. The mycelia composing the sclerotia are very irregular and septate (fig. 14).

SUMMARY

1. The dahlia root rot is caused by a species of *Botrytis*, corresponding very closely to the description of *B. cinerea* (Syn., *B. vulgaris*).
2. The infections are always through wounds; it is impossible for them to occur through the uninjured epidermal covering.
3. The young mycelia tend to unite or conjugate by means of short mycelial tubes which usually come out at right angles. In order that this

union may occur, the mycelia must be young and at a distance not to exceed 10 microns.

4. Growths similar to, or the same, as those described by other writers as "hold fasts" always developed into sclerotia.

LITERATURE

- (1) PRICE S R Peculiar spore forms of Botrytis. New Phytol. 10: 255-259. 1911
- (2) SMITH R E Botrytis and Sclerotinia: their relations to certain plant diseases and to each other. Bot. Gaz. 29: 369-407. 1900.
- (3) ————The parasitism of Botrytis cinerea Bot. Gaz. 33: 421-436. 1902
- (4) WARD, H MARSHALL A lily disease. Ann. of Bot. 2: 319-380. 1888.

NEW JERSEY AGRICULTURAL EXPERIMENT STATION
NEW BRUNSWICK, NEW JERSEY

EXPLANATION OF PLATE VII

- FIG 1 Fragment of mycelium
FIG 2 Conidiophores
FIG 3 Conidiospores
FIG 4 Germinating spores
FIGS 5-9 Stages of branched mycelium in formation of sclerotium
FIG 10 Young sclerotium
FIG 11 Later stage of sclerotium
FIGS 12 a 12 b Union of mycelia from two spores
FIG 13, a-m Union of mycelia
FIG 14 Fragments of mycelia from sclerotia
(Figures 1 and 12b were drawn with No. 2 ocular and $\frac{1}{4}$ oil immersion all others with No. 2 ocular and $\frac{1}{8}$ dry objective)

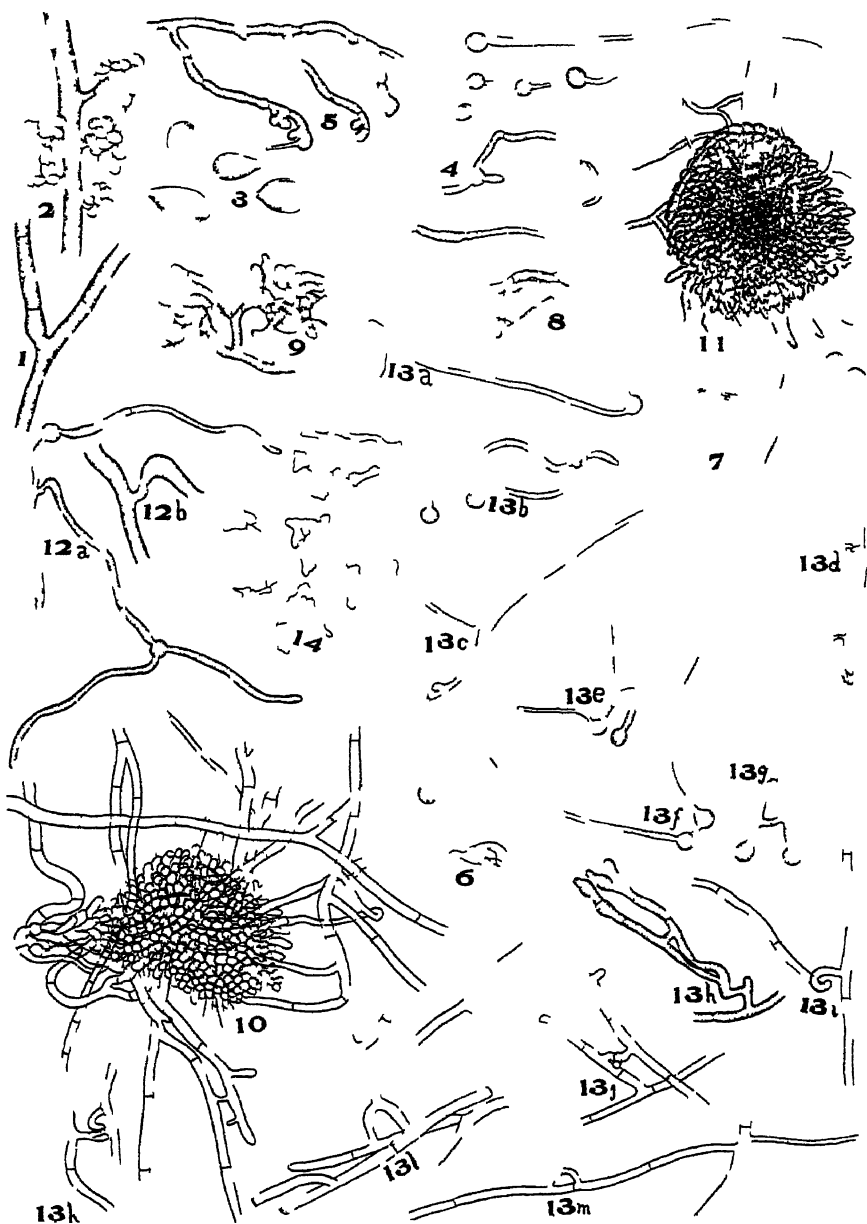


PLATE XVII BOTRYTIS DISEASE OF DAHLIAS

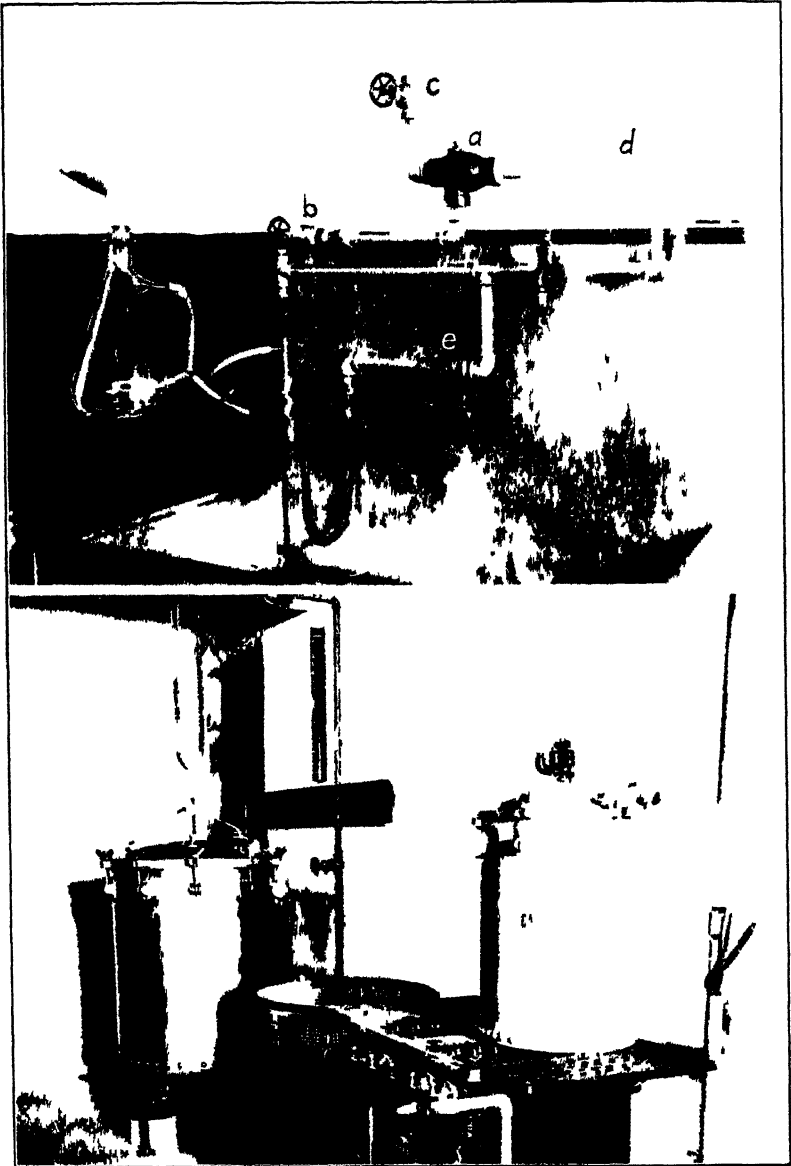


PLATE XVIII LABORATORY EQUIPMENT

SOME BORROWED IDEAS IN LABORATORY EQUIPMENT

W. J. MORSE

WITH PLATE XVIII

In connection with the plant pathology laboratory of the Maine Agricultural Experiment Station there is a basement room which is fitted up for dish washing, sterilization, etc. In this room we have in use certain devices and pieces of apparatus which are either homemade or are adaptations of articles designed to be used for other purposes. Several of these result in the saving of much time and labor and are a constant source of satisfaction to all concerned. The following descriptions are given of some of these, with the idea that they may be of possible service to others engaged in similar lines of work.

Figure 1 represents some attachments connected with the dish washing sink, including a water heating device, an apparatus for rapid and thorough rinsing of test tubes, flasks and other glassware, and illustrates our method for rapid filtration of liquid culture media by suction. Figure 2 shows an inexpensive, portable autoclave and a much larger one of the same type, permanently connected with the steam service pipes and used for soil sterilization.

Water-heating device. Comparing the cost of installation and utility this is perhaps the most satisfactory piece of apparatus in the lot. The essential part of it is the suction-tee shown at *a*. A suction-tee is a fitting in common use among steam fitters and is constructed on practically the same lines as the common filter pump. It is designed for elevating liquids short distances by means of steam pressure and is frequently employed for pumping bilge water from the holds of small steamboats. The present use is an adaption.

For water heating the cold water is introduced into one side from below, the supply being controlled by the valve *b*. The steam supply is regulated by valve *c*, and enters the suction-tee at the left. The hot water emerges at the other end into the discharge pipe *d*. The horizontal part of this pipe which connects with the suction-tee is $9\frac{1}{2}$ inches between fittings. The lower part of the discharge pipe swings back against the wall when not in use.

The entire cost of this water heater including labor and materials for installing was only a little over \$3. The low cost was partly due to the

fact that water connections were already in the sink and the steam supply was obtained by tapping a pipe which ran directly overhead. By its use a $\frac{1}{2}$ -inch stream of almost boiling water can be obtained instantly and maintained as long as desired. By simply adjusting the valves the temperature of the water can be raised to any degree desired from that of the service pipes up to 85 or 90°C.

If installed in the manner illustrated there is no pounding in the pipes when the steam and cold water come together, and very little noise can be heard when the heater is in use—certainly nothing which would be objectionable in any laboratory. Both high and low pressure steam can be turned into our supply pipe and we have used from 3 to 20 pounds with equal success. With the lowest pressure steam the cold water supply must be reduced somewhat but even then the supply of hot water obtained is ample. In use the steam valve must always be opened last and closed first.

Test tube rinser. This is an adaptation of the method employed in washing and rinsing bottles in bottling establishments and in rinsing drinking glasses at soda fountains. It has been found invaluable as a time saver in washing and rinsing test tubes which have contained cultures. Moreover the rinsing can be much more thoroughly done in this way than in any other that the writer has seen in use. It is simply a small brass tube bent in the form of a broad U. One end is connected with the water pipe and the other or open end points directly upward. In use the operator, holding the article to be rinsed in his left hand, places it over the open end of the pipe and with his right hand turns on the water at the valve *e*. The connection is made to the water pipe by a small brass union which has a ground joint and which allows the tube to swing with the attached arm of the U as an axis. Hence this also may be turned back against the wall of the sink when not in use.

Filtering apparatus. This is largely self-explanatory as shown at the left in figure 1. It consists of a 2-liter flask and a Buchner funnel attached to a filter pump. The funnel is about 17 cm. across the bottom and holds approximately a liter and a half. By placing a circular filter paper flat on the perforated bottom of the funnel and then applying suction, liquid culture media may be filtered much more rapidly than by ordinary methods. It is first necessary to run a small quantity of distilled water through the funnel to wet the paper and just as the last of it is passing through the paper should be pressed down with the fingers at the edges to stop possible leakage. If agar or gelatin are to be filtered a quantity of boiling water should be run through first, to thoroughly heat up both flask and funnel. A large dinner plate is sometimes put over the funnel for a cover, after first dipping it in boiling water. This helps to retain the heat in the case of slow filtering agar. Also in filtering gelatin and agar it is best to remove the

major portion of the coarser particles by first passing through a cotton filter.

Portable autoclave. This is a "home canning boiler" which with safety-valve and steam gage retails for about \$15. It is made of boiler iron, 17 inches high and 12½ inches in diameter inside. It is built on the lines of the old style autoclaves and is designed to be used in the home on the kitchen stove. Hence it is well adapted for use in temporary field laboratories or in secondary schools or other institutions where the cost of the ordinary form of autoclave would be prohibitive.

Soil sterilizer. Some form of soil sterilizer is absolutely essential for carrying on work in plant pathology where inoculation studies are made in the greenhouse. It is necessary, if for no other purpose than to prevent the spread of new or rare diseases by means of discarded potting soil. The large autoclave shown at the rear in figure 2 is one of the larger (factory size) boiler-iron canning retorts put out by the same concern which makes the portable canning boiler. This is 30 inches high and 24 inches in diameter inside. Six 10-inch or twelve 9-inch pots of soil can be sterilized in it at one time.

This sterilizer is provided with a steam gage, safety-valve, air cock, and thermometer. The wire basket, standing next beyond the gas range, may be placed within the sterilizer as a container of the articles to be processed, if desired. The cover is of cast iron and quite heavy. A patent pulley block which automatically locks and holds the load at any height, at the will of the operator, was purchased and attached to the cover by means of iron hooks inserted in the handles. By this means the cover can be raised and lowered easily, or suspended, as desired.

MAINE AGRICULTURAL EXPERIMENT STATION

ORONO, MAINE

THE BARBERRY AND ITS RELATION TO BLACK RUST OF GRAIN

H T. G U S S O W

Many years before the distinguished mycologist, Anton de Bary, of the University of Strassburg had shown by scientific investigation (in 1865) that the barberry (*Berberis vulgaris* L.) played an important rôle in the spreading of black rust of grain (*Puccinia graminis*), practical farmers on the continent of Europe were convinced that the rust specks on the barberry had some connection with the grain rust. Naturally, the interpretations of this observation were mainly fantastic. Within recent years, and as the knowledge of the life history of these destructive grain parasites advanced, the fact that barberry rust and grain rust were closely related became more and more established. It was clearly proven that the barberry served as an intermediate host for the fungus on grain. However, there has been entertained considerable doubt or lack of appreciation as to the correctness or practical use of this observation, which was regarded as mere theory. It was pointed out by several investigators that in certain districts of Hungary and Sweden very few barberry bushes existed, and still black rust seemed to persist. Dr. Barclay, a famous mycologist of India, cited a particularly interesting example, referring to the grain growing district of the East Indies where there is no barberry to be found within 300 miles of that area. However, beyond this distance in the mountainous regions there were barberry bushes growing. We may note that although in these cases "there were hardly any barberries left" or "they were 300 miles away from a grain growing district" yet there certainly existed some barberries all the time. One of the first European countries which took the matter seriously was Denmark. By means of a legislative act this country enforced the systematic destruction of the barberry. It has been stated by Dr. Lindau in 1908, that notwithstanding the destruction of the barberry, black rust of grain continued its devastations, although the intensity of infection varied to some extent. This latter observation, of course, may be commonly made any one year, the rust varying considerably according to districts or climatic conditions.

In the report of the Dominion Botanist of Canada for 1911, p. 239, the present status of our knowledge of rusts was briefly summarized, and it was stated that it had been found in Denmark, for instance, that the compulsory destruction of barberry has not brought a reduction in the severity

of rusts. This statement was eventually read in Denmark, and we are indebted to Dr. J. Lind of the Phytopathological Experimental Station, Lyngby, Denmark, for a letter in which he refers to this statement explaining that "*Puccinia graminis* is quite perceptibly disappearing in Denmark year by year to the same degree as we get rid of the Berberis, and we are very well satisfied with the results of the Berberis Act."

This communication contained important information of a more definite character than any we have been able to secure previously. We thought it, however, desirable to seek the opinion of another Danish plant pathologist and communicated with Dr. F. Kølpin Ravn of the Pathological Museum of Copenhagen. He very courteously writes us under March 26: "In your letter of February 27 you desire to know what my personal experience has been concerning the extermination of barberry bushes in this country. I have been able very often to observe early outbreaks of *Puccinia graminis* on rye and oats; in all such cases—without any exception—we have been able to find some barberry bushes near by; and some years after the removal of these bushes these early outbreaks of rust had disappeared."

Several of the Local Advisers in Plant Culture carried on a systematic fight against the barberry bushes, as required under the Act. And at present the early—and only dangerous—outbreaks of black rust are rarely reported. I may add that the farmers have practiced for some recent years sowing spring grain earlier than before, which further helps in the fight against the rust. I think, therefore, that the present very slight infections by *Puccinia graminis* are the results of the two named factors taken together."

From these two letters it would appear that the systematic destruction of the barberry *Berberis vulgaris*, green and purple-leaved,—for the aecidia of the rust fungus occur on both—would produce a very desirable effect, i.e., the checking of the severity at any rate, of that most dangerous rust of grain culture.

The barberry shrub, it must be realized, is worthless as compared with the immense value of cultivated grain. In order to protect the grain industry as much as possible the destruction of the barberry wherever it grows is strongly advocated.

DIVISION OF BOTANY

DEPARTMENT OF AGRICULTURE

EXPERIMENTAL FARM, OTTAWA

BLACK HEART OF POTATOES

E. T. BARTHOLOMEW

WITH PLATE XIX

Within the past two years the Department of Plant Pathology of the University of Wisconsin has received several samples of potatoes (*Solanum tuberosum*), showing a blackening of the tissues, especially in the central regions. The term "black heart" has been suggested as most suitable for the description of this abnormality. These samples came from widely distant points but in all cases were taken from carload shipments of potatoes, either while they were in transit or soon after they had reached their destinations. The first report came to Prof. L. R. Jones from Dr. W. J. Morse, of the Maine Experiment Station, who sent a photograph in the winter of 1911, showing this condition in potatoes that had been shipped from Maine to Virginia. In recent correspondence on the subject Dr. Morse says that the trouble was first brought to his attention from Virginia shipments in 1910 by Mr. W. A. Orton, and adds that several Maine potato shippers with whom he has talked report that in their experience the condition is likely to occur where potatoes are overheated in transit.

Specimens were received from a leading produce company of Kansas City, Missouri, in February, 1912, who reported the trouble in three carloads of potatoes just received from Wisconsin which they suspected had been chilled or overheated in transit. In February and March, 1913, similar samples were received from one of the large wholesale potato dealers of Chicago, taken in each case from car shipments upon arrival in Chicago. Professor Jones arranged to have this company advise him promptly upon the arrival of another such shipment that detailed examination might be made and further data secured. Notice was received on March 3 and H. E. Dibble, being especially interested in potato diseases, went to Chicago to investigate conditions. He found that the trouble had occurred in a carload of potatoes just received from northern Wisconsin. These were supposed to be normal before shipping. They had been four days in transit, shipped in a refrigerator car which in order to prevent the potatoes from freezing had been heated with a wood stove. The potatoes, which were in sacks, filled the car, except for a narrow space in the center occupied by the stove. The method of "firing" is to build a hot fire in the stove when the car is started, then close the door tightly and leave it as

long as seems safe from frost, when the fire is again started. In this way the car had been "fired" probably three or four times in transit. Upon opening in Chicago the temperature was still high, perhaps 25°C. Evidences of the extremes of temperature that had occurred during transit were found in the fact that while some of the potatoes in the ends of the car were frosted, those taken from the sacks nearest the stove were baked as nicely as if from a kitchen oven.

Examination of the blackened tissues in both 1911 and 1912 showed them to be sterile and the evidence from Kansas City and Chicago agreed with that from Dr. Morse in indicating that temperature conditions, either alone or in combination with the atmospheric composition, were responsible for the trouble.

The writer, being especially interested in physiological problems, undertook to supplement Mr. Dibble's observations by laboratory treatment of tubers with the aim of producing black heart artificially. Experiments previously conducted by Mr. Dibble had shown that chilling did not induce the typical trouble. The writer, therefore, tried heating at various temperatures both in ordinary atmosphere and in other gases.

The artificial production of black heart in potatoes under laboratory conditions was not found to be a difficult task. The abnormality was produced when potatoes taken in April and May from the storage cellars were exposed to a temperature of about 38° to 45°C. in an ordinary drying oven for from eighteen to forty-eight hours, depending somewhat on the size and variety of the potatoes. Ten different varieties have been tried and each responds more or less readily to the test. So far, it is not evident that the presence of an excess of either oxygen or carbon dioxide influences the physiological changes which occur in the potato while being heated. Nor is the chilling, such as that to which the potatoes were exposed while in transit, necessary to bring about discoloration, for the potatoes used for experimentation in the laboratory were taken directly from the storage cellar, and exposed to the above temperatures. On the other hand, experiments show that the chilling tends to retard rather than to accelerate the physiological changes producing the abnormalities.

The blackening does not develop to the same extent in all potatoes. Apparently the change begins in the center and radiates toward the margin (see pl. XIX, figs. 5 and 6). In some cases, however, half or even more of the central portion of the potato is blackened with no radiations (figs. 1 and 2). It is usually impossible to tell, before cutting open, whether or not the potato is normal since the discolorations, except in extreme cases, do not extend to the epidermis, and the eyes are not killed. If the abnormal potatoes are allowed to remain from ten days to two weeks before cutting open, the blackened tissues in the center shrink, leaving a hollow

with a black lining (figs. 3 and 4). The discoloration is black and entirely different in appearance and distribution from the malady variously known as "internal brown rot," "sprain" and "Eisenfleckigkeit." Nor should this trouble be confused with ordinary "hollow heart."

The degree of success accompanying the laboratory experiments can be shown best by figs. 2, 3 and 5, pl. XIX. These should be compared with figures 1, 4 and 6, which are photographs of potatoes taken from the refrigerator cars mentioned above. The black heart induced in the laboratory is thus apparently identical in every respect with the cases developed in the car shipments.

The evidence at hand leads us to believe that this trouble is not at all uncommon. No doubt other shipping parties have encountered the trouble without reporting it and it is not at all improbable that black heart may be developed in potatoes which are stored in such places as warm cellars and in pits covered with manure.

Further particulars concerning the production of black heart artificially and the physiological changes which cause the blackening and finally the shrivelling of the affected tissues will be treated in a future article. For the present, however, it is important to note that black heart may be produced in potatoes that have been stored during the winter by keeping them for a certain period of time in a temperature of about 40°C.

UNIVERSITY OF WISCONSIN

PLATE XIX. BLACK HEART OF POTATOES

FIGS. 1, 4 and 6 were from car shipments; 2, 3 and 5 were produced by heating in the laboratory oven. The cavities shown in 3 and 4 are secondary developments following the death of the tissues.

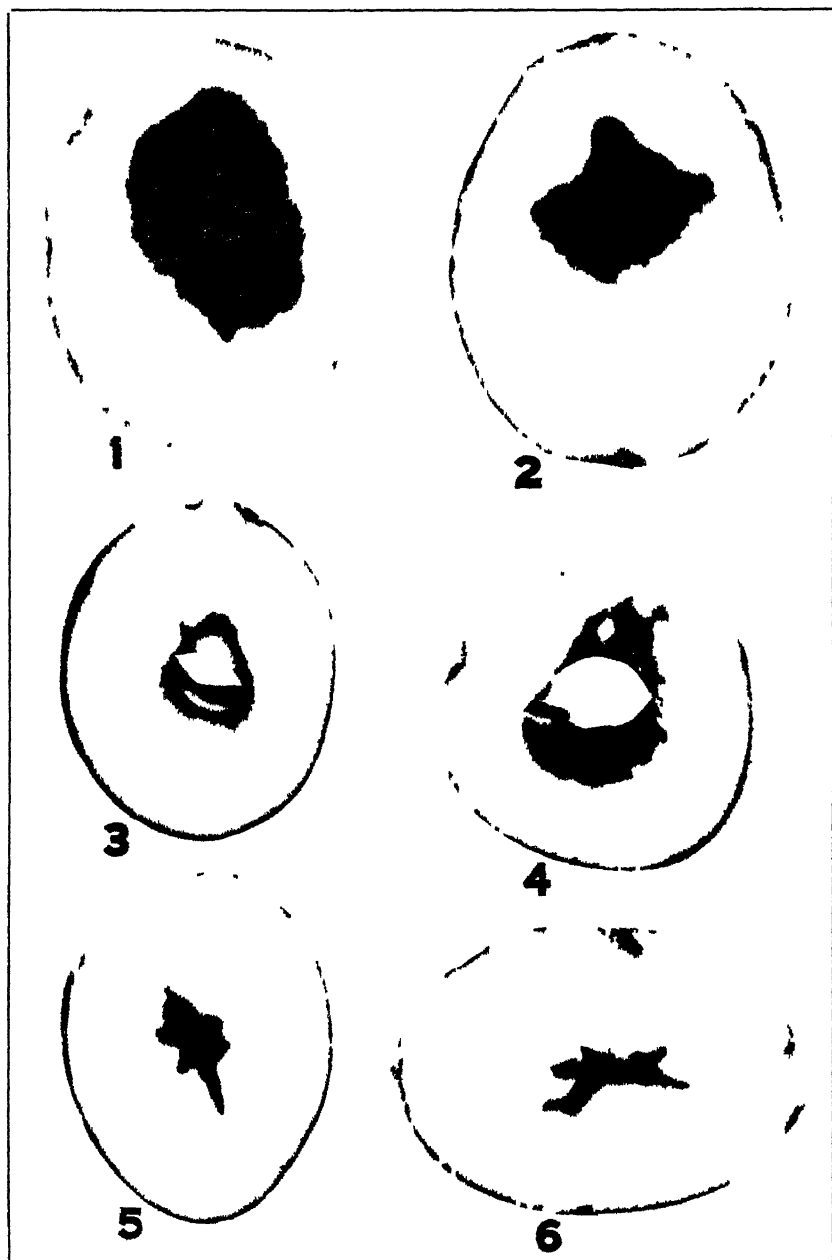


PLATE XIX BLACK HEART OF POTATOES

FUSARIUM OR VERTICILLIUM ON OKRA IN NORTH CAROLINA?

GILBERT WILSON

In a recent article Doctor Wollenweber¹ refers to a short paper by Stevens and Wilson² on okra wilt, saying that they found "black sclerotia in pure cultures of the parasite, which they call *F. vasinfectum*. To judge from this and my positive results obtained with *Verticillium* on okra, they may have worked with *Verticillium albo-atrum* and not with a *Fusarium*." This refers to the statement, "Perhaps the most interesting feature developed in the cultures was the uniform presence of numerous black sclerotia-like bodies similar in structure to those described by Appel and Wollenweber for *F. solani* and related species. These appear to be of the nature of sporodochia, as they are associated with conidia production."

In making the assumption which he does Doctor Wollenweber is inconsistent with a fundamental dictum which he announces earlier in his paper, when he says, "We need, therefore, a pure culture method which gives the normal stages and, if possible, all stages, of a fungus." Students of *Fusarium* and related forms have reached the conclusion that agar media do not meet this requirement, as numerous abnormalities often develop in cultures on such media, yet he takes the results obtained by cultures on agar and compares them directly with those obtained by culture methods which experience has shown are much better suited to bring out the normal development of the fungus.

Since the article, of which the present writer is one of the authors, is not over detailed and explicit on certain points, and, from the above, evidently open to misinterpretation, a more complete statement concerning this disease appears not inappropriate, especially in view of the importance of this class of diseases of which it is an example.

During the season when the study was made okra wilt was not uncommon around Raleigh, and a few wilted plants were noted in the succeeding year. As other fusarial wilts are not uncommon in the state their relation-

¹Wollenweber. Studies on the *Fusarium* problem. *Phytopathology* 3: 24-50. 1913.

²Stevens & Wilson. Okra wilt (fusarirose), *Fusarium vasinfectum*. *North Carolina Agr. Exp. Sta. Ann. Rept.* 24: 70-73. 1912.

ship to each other has naturally been kept in view by the station workers who have come in contact with them.

The disease was studied, not primarily from the morphological standpoint, but more especially for the identification of the causal organism. These studies were made by means of moist chamber cultures on okra stems, and pure cultures of the fungus on pea agar. In neither case did the fungus agree with the characterization of *Verticillium albo-atrum*, as it formed sporodochia with conidia which were falcate and usually 3-septate, never unicellular and ellipsoid. So far as observed the "sclerotia-like bodies" upon which Doctor Wollenweber bases his conclusion as to the identity of the North Carolina fungus never occurred on okra stems either in the field or in cultures, but were confined to the fungus when grown on agar. They began by the formation of a single enlarged, dark-colored cell in the vegetative mycelium. In the course of a few days a mass, easily visible to the unaided eye as a black speck, had developed from the cell. Cultures might contain only completely formed bodies, or they might be present in other cultures in all stages of development. Without awaiting a period of rest these bodies immediately developed conidiophores and conidia in the same manner and of the same form as those which developed on the okra stems. It would appear, then, that these bodies were not sclerotia, but stromata, which, according to our critic, "may form an aerial or immersed mycelial layer, the consistency of which is either loose or plectenchymatic (pseudoparenchymatic)." That these bodies are to be regarded as stromata rather than as sclerotia was the idea intended to be conferred in the original statement.

The fungus studied at Raleigh was not *Verticillium albo-atrum*, but a species of *Fusarium*, which in view of the present confusion within the genus was not inappropriately designated *F. vasinfectum* Atkinson, since the type host of that species (cotton) is sufficiently closely related to okra to justify such a provisional reference of the fungus in question.

As no mycologist will entertain, even for a moment, the idea that all fungi, even of a given order, which attack a common host must per se be referred to the same species without first making a careful comparison of the various material, we must conclude from the statement of Doctor Wollenweber that there appear to be two wilt diseases of okra in this country, both showing the same symptoms, but caused by quite distinct and comparatively unrelated fungi, unless by some chance the material which he studied possessed only immature or abnormal conidia. That Doctor Wollenweber should assume merely on the basis of the published account and without examining material of the North Carolina fungus that the species studied by Stevens and Wilson is identical with the one which he refers to as a species of *Verticillium* appears to be due to his

loose use of such terms as sclerotium and stroma. According to his own definitions of these terms, each of them, when applied to fungi in general, is capable of widely varying interpretation since they include bodies of entirely dissimilar origin and structure, to say nothing of the fact that in neither case are they of necessity constant either in their behavior or the part which they play in the life history of the fungus which produced them.

COLUMBIA UNIVERSITY

REVIEWS

Die Nekrose des Phloëms der Kartoffelpflanze, die Ursache der Blattrollkrankheit. Quanjer, H. M. Mededeelingen van Rijks Hoogere Landtuin- en Boschbouschool (Wageningen, Holland). Deel 6: 40-80. Taf. 2-9. 1913.

This paper takes up the anatomical and physiological questions relating to the leaf roll of the potato. The author finds that the chief cause of the disease shows itself in the phloëm strands. The sieve tubes are shrunk so that the walls and lumina of the single tubes cannot be differentiated. This shrunk tissue is yellowed, and with acids and caustic potash gives the characteristic reactions of lignified cells. Another variation from the normal is the shortening of the members of the sieve tubes in the mature internodes of the diseased plants.

The physiological disturbances are traced back to the shrinking of the phloëm strands, which causes a checking of the sap flow, thereby indirectly producing the disease symptoms, such as rolling of the leaf, dwarfing, aerial tubers, etc. The occurrence of oxidizing enzymes in the plants is considered to be a response of the plant to the stoppage of the sieve tubes, and not the cause of the disease.

The statements made are logically brought out, but the failure of the author to go into detail as to the experimental evidence on which they are based considerably weakens the points made.

The report is valuable, however, because it opens up new lines of work on this important disease.

J. C. GILMAN

Color Standards and Color Nomenclature. Ridgeway, Robert. Published by the author, Washington, D. C. Octavo, 43 pages, 53 colored plates. Price, \$8.00.¹ 1912.

Exactness and precision are of the utmost importance in phytopathology, as in all other branches of science, and any practical assistance in attaining these ends should be welcomed and utilized by all. Color standards and nomenclature have until recently been in a very crude and unsatisfactory condition. The names applied to colors in descriptive pathology and botany have usually been taken from popular parlance. Such names do

¹ Copies may be obtained from Mrs. Robert Ridgeway, 3447 Oakwood Terrace N.W., Washington, D. C.

not convey any exact idea, and hence mean different things to different individuals. The book before us is intended to obviate this difficulty and provide biologists and allied scientists with an exact and adequate set of colors and color names.

The author published a work on the same subject over twenty-five years ago, containing 186 named colors. This of course was very incomplete and inadequate for scientific purposes, though it proved very useful and paved the way for something better. The present work, which contains 53 plates and 1115 named colors, is the result of the continued patient industry and investigation of Mr. Ridgeway, with the assistance of various artists and naturalists whose help he gratefully acknowledges. The classification of the colors is based on the fundamental colors of the solar spectrum which are connected by the intermediate colors. The exact proportion of two or more colors necessary to produce any given color has been determined by the color wheel and Maxwell disks. This makes it possible to reproduce at any time any one of the 1115 colors if it were lost. Each of the colors is given a separate name besides being designated by a number and letter on the plate. It has required considerable ingenuity to find individual names for each of the colors. Some of them are consequently not so simple as one might wish. This seems however to have been unavoidable. The amount of manual labor involved in preparing each color separately and pasting the color slips on the plates has been great and this accounts in part for the rather high price of the book. The colors are as near permanent as it is possible to make them at present. The accurate definition of color terms, such as hue, tint, shade, and tone help greatly to clarify the subject. The book meets the needs of the biologist and pathologist better than any work of the kind that has yet appeared. Its adoption and use by phytopathologists and mycologists would greatly promote the advancement of our work, and it is to be hoped that it will find a place in the library of every scientific institution.

C. L. SHEAR

(On the rotting of potato tubers by a new species of *Phytophthora* having a method of sexual reproduction hitherto undescribed. Pethybridge, G. H. Sci. Proc. Royal Dublin Soc. **13** (N. S.): 529-565, pl. 42-44. March 1913.

(On pure culture of *Phytophthora infestans* deBary, and the development of oospores. Pethybridge, G. H. and Murphy, P. A. Sci. Proc. Royal Dublin Soc. **13** (N. S.): 566-588. pl. 45-46. March, 1913.

The first of these papers describes a new species, *Phytophthora erythro-septica*, causing a "pink rot" of potato tubers. The disease is prevalent

in the west of Ireland and the losses caused by it are considerable. The tubers attacked are at first resilient like india-rubber. A juice is exuded and soon the tubers dry up, becoming hard and woody. In all stages the mycelium resembles that of *P. infestans*. The conidia are formed only in watery solutions. They are developed sympodially, are ovate, with a blunt apex, and not provided with papillae. The size varies but averages 32μ by 20μ .

Antheridia and oogonia are produced in culture on separate hyphae. The antheridium is first formed and is a rounded structure which may be lateral, intercalary or terminal. The oogonial incept may be similarly formed. If the oogonial incept comes into contact with an antheridium, it enters into the interior of the latter, usually penetrating near the base; if it does not meet with an antheridium, development appears to be checked, at any rate no oogonium is formed. After a few hours it begins to grow, and soon breaks its way out through the summit of the antheridium, when the formation of the oogonium proper begins to take place. When the oogonium has attained full size, the passage of granular protoplasm ceases. Later the contents of the antheridium disappear. It is not certain whether fertilization occurs, but if so, it would appear to take place before the formation of the oosphere. Gradually a definite sphere is produced within the oogonium, the wall of which ultimately becomes about 2μ thick, and is very slightly tinged with a yellowish-brown color. The diameter of the oospores is between 29μ and 30μ .

After working out this method of oospore formation in *P. erythro-septica*, attention was directed to *P. infestans*. Pure cultures were grown and all the results were secured by means of these, following the methods developed in this country by Jones and Clinton. Oospores agreeing in all respects with those described by Clinton were secured on a modified form of oat agar. Search for resting spores in diseased potato tissues has thus far been fruitless. The oogonia arise as terminal swellings, the contents become dense and the wall brown in color, thus hiding from view changes undergone by the contents. These oogonia are pyriform to spherical in shape, averaging 38μ in diameter. When full grown a septum shuts the oogonium off from the contents of the hypha which bears it. The course of events where the antheridium is formed is probably similar to that in *P. erythro-septica*. It is finally observed that the antheridia are oval structures borne at the tips of hyphae. The oospore is contained within the spherical portion of the oogonium, the lower tapering portion of which is actually within, and surrounded by, the antheridium.

It is suggested that those species whose sexual organs are developed according to this new erythro-septica type should be retained in the genus *Phytophthora*, and that those which follow the cactorum type should be

placed in a new genus for which the name *Nozemia* is suggested. The genus *Phytophthora* as amended is to be removed from the family Peronosporaceae, and to constitute the sole member, at present, of the new family Phytophthoraceae. The members of the new family would be *P. erythro-septica*, *P. infestans*, *P. Phascoli*, and (doubtfully) *P. Arecae*.

H. G. MACMILLAN

PHYTOPATHOLOGICAL NOTES

Melanose. Melanose is one of the diseases of citrus fruits which, because of its economic importance, has been the subject of investigation both by plant pathologists and physiologists. A glance at the literature of this malady impresses one strongly of the fact that a diversity of opinion exists as to its etiology. Announcements have appeared within the last few months in some of the scientific journals that the cause of this disease has been definitely established as the result of some work conducted at the Florida Experiment Station.¹ However, upon carefully reading the report of these investigations, it is not apparent to me from the evidence submitted that one is justified in concluding that *Phomopsis citri* Fawcett is the cause of melanose. It is the present purpose, therefore, merely to call attention to the nature of the proof submitted.

Plant pathologists have come to recognize, along with animal pathologists and professional bacteriologists, that proof of the pathogenic nature of an organism consists in its fulfillment of four cardinal requirements, which are known as Koch's rules. *Phomopsis citri* as the cause of melanose can, therefore, be justly submitted to these rules of proof in answer to the charge of pathogenicity which has been preferred against it.

As to the constant association of the organism with the disease several quotations only will be sufficient. "Microscopical examinations were made of these (referring to melanose spots on leaves, twigs, and fruits)² but in no case was a fungus or a bacterial organism connected with the spots which could be considered a cause of the disease. Stained sections of diseased tissues failed to show the presence of fungus growth within the affected or adjoining cells." In another portion of the text, however, an apparently different impression is left by the following statements: "Particles of fungus hyphae can sometimes be distinguished in the affected tissue. But it has not been demonstrated whether these are parts of the causal organism or are accidental."

Repeated attempts by the authors to isolate this organism from the diseased tissues failed to give satisfactory results, because of the fact that a species of *Colletotrichum* overran the cultures. That *Phomopsis citri*

¹ Floyd, B. F. and Stevens, H. E. Melanose and stem-end rot. Fla. Agr. Exp. Sta. Bul. 111: 1-16. figs. 9. December, 1912.

² Material in parentheses inserted by writer.

can be grown on artificial media is evident from the fact that Fawcett¹ isolated it from more than fifty different specimens of fruits and branches from more than twenty-five different localities.

The statements relative to inoculation into healthy plants are, unfortunately, so lacking in detail that the reader cannot account for the conclusions which are drawn. One method of inoculation consisted in drenching two trees with the drippings from dead twigs, then covering one tree for thirty-six hours with a bell jar and permitting the other to remain uncovered. Only the tree which was covered developed the characteristic spotting, from which it was concluded "that the spotting came from the dead twigs"! None of the fungi obtained in the plate cultures of unfiltered washings from dead twigs were capable of producing melanose. "No spotting has yet resulted by using the vegetative portion or mycelium of this fungus in infecting young tissue." Again, quoting in explanation of the infection work which involved the use of pure cultures of conidia, they say, "Apparently no vegetative growth of the fungus takes place within the infected tissue," so that no evidence is at hand relative to penetration. It is further suggested that the spots may be formed as a result of some stimulating or toxic effect produced by the germination or death of the conidia. This is indeed a wholly unique type of parasitism!

Further, there is no evidence submitted of attempts, either successful or otherwise, at reisolation from inoculations. There is, therefore, an apparent breach of every rule of proof in the evidence at hand as to *Phomopsis citri* being the cause of melanose.

FREDERICK A. WOLF

The type of Sphaeria radicalis Schw. Since our recent note² regarding this species, we have been able through the kindness of Prof. H. O. Juel, of the University of Upsala, Sweden, to examine asci and ascospores from the type specimen which was sent by Schweinitz to Fries and evidently used by Fries in the preparation of his description.³

We wish to express here our gratitude to Professor Juel for his courtesy in helping us to determine beyond any reasonable doubt the identity of this fungus. But one autograph specimen of this from Schweinitz could be found in Fries' Herbarium. It is labeled "*Sphaeria radicalis* L. v. S. Salem." It consists of two pieces of bark apparently from an oak root. One piece shows distinct perithecia with necks and ostioles agreeing with

¹ Fawcett, H. S. The cause of stem-end rot of citrus fruits (*Phomopsis citri* n. sp.) *Phytopathology* 2: 109-113, pls. 8-9. 1912.

² *Phytopathology* 3: 61. February, 1913.

³ *Elenchus Fungorum, Sistens Commentarium in Systema Mycologicum*. 2: 73. 1828.

Fries' description. The other piece seems to show pycnidia only. Measurements of nearly 100 ascospores from this specimen range from 5.5 to 9.2 by 2.7 to 3.8 microns. In all the characters studied the specimen agrees essentially with typical material of *Endothia virginiana* And. & And. kindly sent us by Mr. P. J. Anderson. Our measurements of ascospores from Anderson's specimen were 5 to 9 by 2.8 to 3.8. These differ somewhat from the measurements given in the original description of *Endothia virginiana*. There seems to be no doubt, however, of the identity of these two species. We have recently collected typical specimens of *Endothia radicals* (Schw.) in the type locality, Salem, N. C. The species does not appear to have been collected, as yet, north or east of York County, Pennsylvania.

C. L. SHEAR

Auricularia mesenterica (Dicks.) Pers. This fungus is very common in Europe. Several collections made by the writer in the deciduous forests of Germany and Austria show it associated with diseased roots of living trees, especially those of *Quercus pedunculata* and *Fagus silvatica*, although it is more often found on dead roots and branches lying about in the forest. The plant seems to be very rare in the United States and few authentic specimens are recorded for this country. It has been reported by Frost from the eastern states and according to Lloyd, has recently been collected in western Canada.

During the fall of the past year two collections of the fungus have been made on dead roots of *Betula occidentalis* in the Bitter Root Mountains, Lolo National Forest, Montana. These collections show a great variety in form and markings of the upper surface. The form showing alternate smooth and hairy zones, formally called *A. lobata*, is less common. The fact that all these forms are found in the same collection indicates that they are one and the same species. The peculiarly wrinkled hymenium, and minute structure of the same, is identical in all. The discovery of this fungus in the western United States is another instance of the wide distribution of a plant supposed to be confined to rather narrow limits.

JAMES R. WEIR

Ginseng diseases. The extension of the work on ginseng diseases that has been under way for the past two years in coöperation between the Cornell Experiment Station and the Bureau of Plant Industry was provided for by the last Congress. The new work will extend the coöperation to the Experiment Stations in Michigan and Wisconsin. Mr. Joseph Rosenbaum will continue as general project leader working especially on soft rots and spraying demonstrations for *Alternaria* and mildew. Mr.

J. A. McClintock will work in Michigan on nematode diseases under the direction of Dr. E. A. Bessey, and Mr. J. W. Brann in Wisconsin on diseases of seedlings and soil treatment under the direction of Prof. L. R. Jones. Ginseng troubles in Pennsylvania, Ohio and other states will also receive attention.

Foreign reviews of American publications. American plant pathologists are requested to send advance copies of their publications to Dr. O. Appel, Kaiserliche Biologische Anstalt, Dahlem, Berlin, Germany, who has kindly offered to secure the prompt publication of reviews.

Federal Horticultural Board. Dr. Perley Spaulding, Pathologist in the Office of Forest Pathology, Bureau of Plant Industry, has been appointed pathologist to the Federal Horticultural Board. Dr. Spaulding will investigate for the Board problems relating to inspection and quarantine against plant diseases, and will assist in organizing an inspection service for the outlying propagating stations of the United States Department of Agriculture. Mr. E. R. Sasser has received a similar appointment as entomological inspector.

International conference on phytopathology. The French government recently extended to the United States an invitation to participate in their International Conference on Phytopathology to be held in Rome on April 25 for the purpose of preparing a draft of an international agreement to be presented to the International Institute of Agriculture which opened its sessions in Rome on May 6. It was found impracticable to accept this invitation on account of the late date of its receipt and because of a provision enacted by the last Congress which requires special authority to be granted by Congress before such an invitation can be accepted or extended.

Personals. Dr. H. B. Humphrey, recently head of the Department of Botany in the Experiment Station and State College of Washington, has been appointed pathologist in Cereal Disease Investigations in the Bureau of Plant Industry, succeeding Mr. E. C. Johnson. Dr. Humphrey is succeeded at Pullman by Dr. Ira D. Cardiff.

John G. Hall, recently associate professor of botany and forestry in Clemson College, has been appointed plant pathologist in the Washington College and Station.

N. Rex Hunt, recently district horticultural inspector for the Okanogan District, British Columbia, has been appointed scientific assistant in the Bureau of Plant Industry.

Anthony Berg, a graduate student in plant pathology at the University of Wisconsin, has been appointed assistant plant pathologist of the West Virginia Experiment Station.

Dr. Erwin F. Smith has been elected to membership in the National Academy of Sciences. The Academy now numbers 125 members, of whom 10 are botanists, viz. Campbell, Coulter, Farlow, Goodale, Harper, Sargent, Smith, Thaxter, Trelease, White. There are two botanists among the foreign associates, DeVries and Pfeffer. Among deceased members the Academy numbered the following botanists, Englemann, Gray, Lesquereaux, Sullivant, Torrey, Tuckerman, Watson: and the following foreign associates, Bornet, Alph. de Candolle, J. D. Hooker, Sachs, and Strasburger.

H. H. Whetzel, professor of plant pathology, Cornell University, sailed June 11 for Bremen. From there he goes direct to Esbjerg, Denmark, where he will join Dr. F. Kolpin Ravn for a botanical excursion with the International Association of Botanists which meets in Denmark the latter part of June. He will spend his summer in the Hartz Mountains, studying the language and collecting pathological material. He will work during the winter with Professor Klebs at Heidelberg and will spend the following summer visiting plant pathologists and experiment stations on the continent. He expects to return September, 1914.

Two Fungi as Causal Agents in Gummosis of Lemon Trees in California. The disease known as gummosis of lemon trees in California is characterized by the dying of areas of bark and the exudation of large quantities of gum above the bud union. That certain types of this disease can be induced in large healthy trees with cultures of fungi has been shown as the result of a series of inoculations during the past year. It was first found that typical cases of gummosis could be transmitted from diseased to healthy trees by inoculations with bits of discolored bark or wood cut out at the advancing margins of diseased areas. Bits of exuded gum or pieces of tissue near the centers of the diseased areas already permeated with gum, in most cases failed to transmit the disease.

In making the first studies of lemon gummosis in the orchards, it was found that there were at least two types of gummosis, one in which the dead bark remained hard, without outward evidence of fungi during the progress of the disease, and one in which the dead bark was at first soft with a later development of fungi upon the surface during damp weather. By a series of inoculations with a number of organisms isolated from both types of the disease, it has been discovered that cultures of *Pythia-cystis citrophthora* Sm. & Sm. (the brown rot organism) are capable of

inducing the former, and that cultures of *Botrytis* sp., probably a strain of *Botrytis vulgaris*, are capable of inducing the latter type.

That the mere cutting through the bark for the purpose of making the inoculations was not sufficient to induce the disease was shown by making cuts without inoculation in the opposite side of the same trees. These, when protected from contamination invariably healed without gumming. As additional checks on some of the inoculations with diseased tissue, bits of healthy tissue of the same size were inserted into cuts on the opposite side of the same set of trees. These also healed readily without gumming.

Some months after inoculation, both these fungi, *Pythiacytis citrophthora* and *Botrytis* sp. were reisolated from the inner bark at the advancing edges of discolored areas, each from its own type of gummosis. A number of different kinds of injuries were made in the same set of trees, such as pounding with a hammer, boring with an augur, cutting and slitting the bark, and striking it with the heel of the shoe, etc. These wounds all healed up without gumming, provided the wounds were made with sterilized tools on bark surfaces that had previously been cleansed or sterilized. Similar wounds, however, most of them on the opposite sides of the same set of trees, when infected with cultures of *Botrytis* were almost always followed by copious gumming and dying of the bark over considerable areas.

Other fungi isolated from diseased tissue and shown by inoculation to be capable of inducing more or less gum with only slight injury to the bark, as compared to the two fungi above mentioned, were *Penicillium roseum*, *Alternaria* sp., and *Fusarium* sp.

That only certain organisms are capable of inducing gum even in wounds, was shown by inoculations into cuts with a number of different kinds of bacteria isolated from diseased tissue, *Penicillium digitatum*, *Cladosporium* sp. from decaying fruits, and *Mucor* sp. from dead roots, without so far producing any effect.

Further investigation of other fungi in relation to gumming is being carried out. A more detailed account of the experiments on which these statements are based is being prepared for a later publication.

H. S. FAWCETT

The nature of the relation, described above, between certain fungi and gummosis has been made the subject of investigation. It has been found that in the discolored bark immediately surrounding the area of gumming there is a substance, filtrable through a Chamberland filter, which is capable of producing gumming when introduced under the bark of a healthy lemon tree. In these experiments the infected bark was ground with sand

and water, the liquid filtered off. and injected under the bark of a healthy tree with a pipette, under sterile conditions. Similar wounds caused no gumming. The liquid used showed the absence of fungus spores and bacteria. It showed the presence of large amounts of oxidase and amylase. In the course of the investigation the effect of boiling the liquid was tried; no gum was produced, while the same liquid, unboiled, caused gumming on the other side of the same tree. Only one experiment of this nature has so far been tried. In no case has the liquid (except when boiled) failed to produce gumming. The question of the presence of active enzymes and their possible connection with gumming is being further investigated.

H. D. YOUNG

The Federal Horticultural Board held hearings on May 20 on the subjects of the pink bollworm of cotton and the white pine blister rust.

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EINE MORPHOLOGISCH PATHOLOGISCHE STUDIE ZUR ABGRENZUNG VON
PILZGRUPPEN MIT CYLINDRISCHEN UND SICHELFORMIGEN KONIDIENFORMEN

H. W. WOLLENWEBER.

MIT TAFELN XX-XXII

A. ZÜCHTARBEIT GESCHLOSSENER ENTWICKLUNGSGÄNGE
PARASITÄRER PILZE

“An den Früchten sollt ihr sie erkennen.” Dieses alte Bibelwort sollte in der Mykologie weit mehr als bisher beherzigt werden. In einer grossen Anzahl von Pilzgattungen ist man bei der Bestimmung noch heute fast ganz auf den Namen der Wirtspflanze angewiesen, deren befallene Organe dann die feinere Einteilung in Blatt-, Stengel-, Fruchtwohner, und so eine Bestimmung nach Saccardo ermöglichen. Oder man gruppiert die Pilze nach den Fundorten in Humus-, Mist-, Fäulniswohner, u. dgl. Häufig setzt man den hohen Grad der Anpassung einiger Pilzgruppen (Brand-, Rostpilze) auch bei anderen voraus. Diese Gewohnheit ist zu einer Art von Grundlage der Systematisierung geworden, hat aber dem Ausbau eines natürlichen Systems sehr geschadet. In einem Ausbau nach dieser Richtung ist uns die Algologie teilweise weit voraus geeilt. Wie sich mehr und mehr herausstellt, gibt es eine Reihe von Pilzgattungen, die in parasitische und saprophytische Sectionen zerfallen. Die Saprophyten scheiden von unserer Betrachtung aus, da ihnen ein hoher Anpassungsgrad nicht zukommt. Anders die Parasiten. Diesen billigt man nicht die Wahl beliebiger Wirtspflanzen und Standorte zu, sondern sucht sie an bestimmten Organen und Orten. Noch heute ist die Anschauung weit verbreitet, dass man Blattparasiten an Blättern, Schädiger der Früchte an Früchten zu suchen habe. Ohne Zweifel kommt man schon mit dieser Annahme zu einem hohen Grade der Erkenntnis. Da man sich aber zu einseitig die Hauptstandorte der Pilze einprägt, so treten diese bei der Bestimmung unbewusst in den Vordergrund. So bei *Cercospora*, *Phoma*, *Phyllosticta*, *Ascochyta*, *Ramularia*, u. s. w. Bei den Ascomyceten ist es nicht besser. Da viele dieser Gattungen bisher kein pathologisches Interesse hatten, lassen sie

eine systematische Grundlage noch heute vermissen. Sie sind Komposthaufen, deren Höhe von der Sammellust der Forscher, nicht aber von dem hohen Stande der Forschung zeugt.

I. UBIQUISTISCHE PARASITEN

Die Erkenntnis, dass viele Pilzgruppen den Ackerbau mehr schädigen, als man annahm, macht es notwendig sie so gründlich kennen zu lernen, dass man sie, um sie bekämpfen zu können, in allen Schlupfwinkeln auf beliebigem Substrate selbst dann erkennt, wenn sie unter der Maske von Saprophyten auftreten. Wir wissen bereits, dass viele Fäulniserreger Saatbeete verheeren und durch das Saatgut übertragen werden, andere vom Boden aus die Saaten heimsuchen. Für die meisten Parasiten aber nahm man stillschweigend an, dass sie nur eine Form der Erkrankung hervorrufen, da nur in wenigen Fällen sekundäre und tertiäre Formen von ein und derselben Krankheit bekannt sind, die von der primären stark abweichen. Um Ordnung zu schaffen, versuchte man, die vermeintlich einheitlichen Krankheitsbilder mit bestimmten Pilzgruppen in Verbindung zu bringen und gegen andere scharf abzugrenzen. Auch dieses Vorgehen hat uns einen guten Schritt weiter gebracht. Man gewinnt aber aus allem den Eindruck, dass die bisherige Pflanzenpathologie mehr in linearen Funktionen vorwärts geschritten ist. Sie steht jetzt auf dem Wendepunkte, wo es notwendig wird, in komplexen Funktionen weiter zu gehen. Die verschiedenen Krankheitskomplexe greifen doch mehr ineinander, als man glaubte. Eine und dieselbe Krankheitsform kann durch mehr als eine Ursache entstehen, umgekehrt kann eine Ursache viele Formen von Krankheiten hervorbringen. Rhizoctonia, der Wurzeltötér, ist von mir (p. 13, 1913) als Erreger einer Tomatenfruchtfäule nachgewiesen. Inzwischen habe ich, beiläufig erwähnt, auch Sclerotium Rolfsii Sacc. als einen der stärksten Wundparasiten an Obst, beispielsweise an Äpfeln, aber auch an Tomaten, erwiesen. Ramularien, die als Blattparasiten bekannt sind, rufen ausserdem Knollen- und Fruchtfäule hervor und finden sich ausser auf Blättern auf unterirdischen Organen und ferner im Erdboden und auf Mist vor. Dieser Nachweis, dass vermeintlich hoch adaptierte Pilze Ubiquisten sind, beruht auf künstlichen Impfversuchen mit zuvor oft jahrelang gründlich morphologisch studierten Pilzen. Es gibt Ramularien mit begrenztem und unbegrenztem Kolonienwuchs, der teilweise in Kultur und Natur ähnlich verläuft. Zahlreiche Isolierungen von Blätter-Ramularien beweisen das, obgleich die Systematik derselben noch nicht bei allen beendet ist.

II. MANGEL AN AUF REINKULTUREN BEGRÜNDETEN MONOGRAPHIEEN

Das Arbeitsgebiet ist noch zu neu, um hier umfassend behandelt werden zu können. Aber die Ergebnisse von Massenzüchtungen der Pilze haben

zeigt dass eine Verschmelzung der Morphologie und Pathologie wichtiger ist als die von Ökologie und Pathologie. Die Verschmelzung soll indes nur soweit gehen, dass die Systematik der Pilze die Grundlage nicht aber das Ergebnis pathologischer Forschung ist. Wir müssen dahin kommen, dass nicht die Pathologie die Bestimmung von Pilzen entscheidet, sondern möglichst die Morphologie. Die Pathologie kann aber die Ergebnisse der Morphologie stützen. In diesem Sinne ist der systematische Teil dieser Arbeit das Ergebnis morphologischer, aber durch pathologische Studien oft gestützter Studien. Die Pilze wurden zunächst rein systematisch bestimmt, nachdem sie in Reinkultur beobachtet worden waren.

Bei den schwierigeren Gattungen der Ascomyceten ist der Versuch nicht gemacht oder nicht gelungen, Monographien auf Reinkulturen des geschlossenen Entwicklungsganges der Pilze zu begründen. Vielleicht hielt man es für unmöglich. Man hat sich vielmehr damit begnügt, die einzelnen Glieder in der Entwicklungskette einer Art mit Hilfe der Reinkultur aufzufinden und aufzuklären, aber nicht immer mit geschlossenen Entwicklungskreisen monographisch gearbeitet. Es genügt aber nicht von einer Ascospore Konidien zu züchten, die einem sogenannten Fungus imperfectus irgend welcher Herkunft ähneln, sondern man muss von dem letzteren die Schlauchform gewinnen, wenn man beide Entwicklungskreise ideell miteinander verknüpfen will. Ja, es ist sogar die Forderung zu stellen, mit jedem einzelnen Entwicklungsstadium eines and desselben Pilzes alle anderen zu erzielen, wenn zweifel an der Identität aller schwinden sollen. Die Fehlerquellen sind selbst bei sorgfältigster Arbeit und bester Methodik noch heute so zahlreich, dass man gar nicht genug Kontrollen und Überkontrollen seiner Studien vornehmen kann. Dass die Züchtbarkeit geschlossener Entwicklungsgänge möglich ist, zeigt sich immer mehr, so auch in dieser Arbeit.

III. DIE KULTUR SEI GRUNDLAGE, NICHT BLOSS HILF-MITTEL DER ASCOMYCETEN-SYSTEMATIK

Für ein gutes Ascomycetensystem fehlen uns noch erfolgreiche in grossem Massstabe vorgenommene Züchtungsversuche. Das gilt besonders für die parasitischen Formen. Die Folge davon ist, dass geschlossene Entwicklungskreise bei vielen Pilzen einzelner Gattungen entweder noch nicht vorliegen oder strittig geblieben sind. Saprophyten wie *Chaetomium*, *Melanospora*, *Neocosmospora* scheiden natürlich von unserer Betrachtung aus, da sie, wie die Literatur beweist, züchterische Schwierigkeiten nicht bieten. Scheinbare Schwierigkeiten sind durch unrichtige Analogieschlüsse allerdings in die erwähnten Gattungen hineingetragen worden. Von *Chaetomium* besitzen wir eine recht gute Monographie von Zopf (*Nova Acta* 41. 1881). Auch Brefeld (1891) hat uns viel Licht gebracht in zahlreichen teil-

weisse monographisch angelegten Studien an Ascomyceten. Aus Ascosporen züchtete Brefeld einzellige Konidien bei einigen, hochentwickelte septierte Sichelformen bei anderen Pilzen. Er fand aber auch solche, die in der Jugend einzellige, im Alter mehrzellige Konidien hervorbrachten. Viele Irrtümer der sonst vorzüglichen Arbeiten Tulasne's, die noch heute in Handbüchern getreulich als Tatsachen gebucht werden, sind von Brefeld bereits ins Gebiet der Fabel gewiesen. Die Vorsicht, mit der die Ergebnisse so vieler Einzelstudien in Handbücher und Praktika übernommen werden, zeigt uns, dass die Beweiskraft solcher Einzelstudien nicht immer ausreicht.

IV. VERWANDTSCHAFT BERUHT AUF MERKMALKOMPLEXEN, NICHT AUF EINZELNEN MERKMALEN

Trotz der grossen Fortschritte der letzten Jahrzehnte werden Merkmale wie das Stroma noch immer überwertet, die Zahl der Öltröpfchen in Sporen festgestellt und Quellungen und Einschnürungen überreifer Ascosporen und Konidien als normal gedeutet und in Diagnosen gebucht. Bei monographischen Studien treten wertlose Merkmale allmählich zurück und wertvolle entsprechend hervor. Ein anderer viel betretener Weg, zu neuen Ideen über Verwandtschaft zu gelangen, besteht darin, dass man ausschliesslich die Literatur einer Gruppe eingehend studiert und dabei zu der Erkenntnis kommt, dass ein einzelnes Merkmal, sagen wir die Zweizahl der Geisseln oder der Pyrenoide bei einzelligen Algen, oder das Stroma oder die Septierung bei Pilzen von höherer Bedeutung ist, als bisher angenommen war. Mit diesem einen Merkmal ausgerüstet, sucht man dann in den verschiedensten Gattungen herum und reist sonst verwandte Formen auseinander, um neue Formenkreise mit einem einzigen einheitlichen Merkmal zu schaffen. Obgleich gegen diese Art linearer Systematik Front gemacht wird, ist sie noch immer geübt. Viel sicherer geht man, wenn neue Gruppierungen nach Verwandtschaft auf Komplexen von Merkmalen aufgebaut werden. Wie schwer aber dieser Komplex ohne Reinkulturen der Organismen zusammenzubringen ist, zeigen die vielen mislungenen Versuche. Die Tatsache, dass auch bei monographischen Arbeiten ohne Reinkulturen Irrtümer sich einschleichen, ersehen wir aus Plowright's Monographie der Gattung *Hypomyces*. Neue Untersuchungen lassen vermuten, dass diese Gattung mehr eine biologische als eine morphologische Einheit darstellt, so dass sie der Auflösung anheimfällt, wenn sich dies bestätigt. Ich habe neuerdings von den Fundorten der *Hypomyces*-Arten, von *Polyporus*, *Lactaria*, u. s. w., eine Reihe von Pilzen isoliert. Ist auch die Erzielung der Schlauchformen noch nicht vorgeschritten genug, um allgemeine Schlüsse zu ziehen, so steht doch fest, dass *Sepedonium* sehr häufig vorkommt und nichts anderes ist als das Chlamydosporenstadium von *Fusarium orthoceras*, das wegen seiner

Häufigkeit als Bewohner höherer Pilze teils mit Hypomyces, teils mit Myco-sphaerella und anderen Ascomyceten verquickt sein mag. Da nun die bisherigen Merkmale für Hypomyces wie Stroma, Ascosporea-Apiculi u. s. w. eher Sectionswert haben und gegenüber Nectria kaum eine Scheidelinie bieten werden, wie umfangreiche Exsiccationstudien mir beweisen, so ist eine monographische Bearbeitung auch dieser Gattung wünschenswert. Sehr wichtige Vorarbeiten verdanken wir v. Hohnel's und Weese's kritischen Studien an Original-exsiccaten beschriebener Nectriaceen, die, im wesentlichen von Nectria ausgehend, allmählich auf eine Reihe anderer Gattungen ausgelehnt worden sind und neben Klärung strittiger Punkte neue wertvolle Ideen über Verwandtschaft bringen. Wohlgeordnete, kritisch referierende Werke wie die von Saccardo, Engler und Prantl, Rabenhorst liefern uns einen Einblick in die grossen Lücken unseres Wissens auf den Einzelgebieten. In ihnen sind Versuche genug gemacht, der For-lerung nach natürlichen Gruppierungen der Pilze gerecht zu werden, aber es ist hervorgehoben, dass der Mangel an Monographien derartige Versuche erschwert oder fast unmöglich macht.

Mehr oder weniger monographisch angelegte Studien wie die Charles Thom's an Penicillium, Carl Wehmer's an Aspergillus, Oscar Hagem's an Mucor zeigen bereits erfreuliche Fortschritte der Reinzuchtmethodik von Konidienpilzen.

Bei vielen Gattungen sogenannter fungi imperfecti so bei Ramularia, Cercospora, Phoma, Phyllosticta u. s. w. ist die unzulängliche aber bequeme alte Methode der Artenanordnung nach Wirtspflanzen bisher beibehalten, sodass in vielen Gattungen noch heute ganz künstliche Systeme obwalten. *Die Unzulänglichkeit solcher Systeme ist dort am fühlbarsten, wo die Bekämpfung ähnlich ausschender Parasiten schärfere Artbegriffe erfordert, um die Arten trotz ihrer scheinbaren Ähnlichkeit unterscheiden zu können.* Bei hochadaptierten Parasiten gelingt die Unterscheidung mit Hilfe der Wirtspflanzen auch da, wo andere Mittel versagen. Die Mehrzahl wundparasitärer Fungi imperfecti aber und Ascomyceten, die zu ihnen gerechnet werden oder zu ihnen gehören, sind noch heute Sorgenkinder der Pflanz-pathologen.

V. ERFOLGE IN DER MASSENREINZUCHT WUNDPARASITÄRER ASCOMYCETEN

Die Arbeiten Shear und Wood's (1913) an Glomerella beweisen, dass die Schwierigkeiten auch in der künstlichen Züchtung parasitischer Ascomyceten überwältigt und mit den Ergebnissen Vereinfachungen der Systematik erzielt werden können. Bei Glomerella herrscht leider eine grosse Formenarmut in Konidien und Schlauchformen vor. Daher ist bei der von genannten Verfassern erreichten Synthese, nach der die Glomerellen von 36

Wirtspflanzen in nur 3 Arten (*G. gossypii*, *G. cingulata*, *G. lindemuthiana*) untergebracht sind, der Schwerpunkt mehr auf die Pathologie und Biologie gelegt, während auf die rein morphologische Unterscheidungsmethode verzichtet worden ist. Vielleicht liefert die letztere aber bei weiterem Ausbau auch für *Glomerella* noch Hilfsmittel der Bestimmung. Ich finde es beispielsweise bemerkenswert, dass die Ascosporen bei *Glomerella* im Längsschnitt eine parabolische bis hyperbolische Dorsale haben, die Konidien dagegen nicht, sodass diese in subnormalen Kulturen oft zu verwechselnden Organe in der Norm leicht unterscheidbar sind und Verschiedenheiten in der Krümmung zur Artunterscheidung mit herangezogen werden könnten. Es sollte ferner den Beziehungen zwischen Apressorien und Chlamydosporen weitere Aufmerksamkeit geschenkt werden, wobei Gloco-porien mit und ohne bekannte Schlauchform zu vergleichen wären. Auch die Ausbildung der Setae ist bei den Arten verschieden und als Unterscheidungsfaktor vielleicht wertvoll. Meine hier referierten Züchtungsversuche an anderen wundparasitären, Ascomyceten wie *Nectria*, *Gibberella*, *Calonectria* und *Mycosphaerella* scheinen ebenfalls dazu angetan, neue systematische Gesichtspunkte zu geben, nach denen natürlichere Gruppierungen möglich erscheinen, sodass wir allmählich auch bei *Hypomyces*, ebenso bei *Spaerostilbe* von biologisch pathologisch zu morphologisch einheitlichen Gruppierungen fortschreiten können.

B. MORPHOLOGIE UND PATHOLOGIE DER BESPROCHENEN PILZE

I. ALLGEMEINE ÜBERSICHT

Obgleich die Morphologie der Pilze genügende Artbegriffe und auch für die Abgrenzung der Gattungen und höheren Gruppen wertvolle Gesichtspunkte lieferte, war eine Stütze durch die Pathologie in vielen Fällen wünschenswert, wie bereits erwähnt ist. Damit glaube ich alle systematisch wichtigen Möglichkeiten berücksichtigt, wenn auch nicht erschöpft und den Weg zu einer befriedigenden Systematisierung dieser Pilzgruppen betreten zu haben. Dennoch werden viele Punkte auf eine scharfe Kritik stossen, besonders die hohe Bewertung der Chlamydospore, die zur Unterscheidung von *Nectria* und *Hypomyces* benutzt ist. Ich züchtete bei *Nectria rubi* Osterw., die ich aus der Centrale in Amsterdam erhielt, aus Konidien in Wasser Chlamydosporen (Tafel XXII, Fig. 16) die noch unbekannt waren und *N. galligena* und *N. discophora* fehlen. Ausserdem hat die Konidienform von *N. rubi* eine höhere Dorsiventralität (Tafel XXII, Fig. 15) als die Vergleichsarten (Tafel XXII, Fig. 2 und 8). Ebenso *Ramularia olida* (Tafel XX, Fig. K). Das Vorhandensein echter Chlamydosporen ist, wie ich in Nr. 1 dieser Zeitschrift äusserte, ein gutes Trennungsmerkmal zwischen *Hypomyces* und *Nectria*, weshalb ich *Nectria ipomoeae* in die Gattung *Hypomyces* gestellt habe.

Brefeld (1891), der mit Reinkulturen von *Hypomyces* erfolgreich arbeitete, erwähnt Chlamydosporen bei *H. chrysospermus* (Tul.), *H. Linkii* (Tul.), *H. pezizae* (Tul.), Sclerotien bei *H. ochraceus* (Pers.), *H. rosellus* (Alb. et Schw.), Plowright fand Chlamydosporen bei *H. Tularensis* Plowr. et Cooke, Reinke und Berthold solche bei *H. solani* Reink. et Berth. Chlamydosporen sind unbekannt bei *H. violaceus* (Schmidt) nach Brefeld (*Nectriopsis violacea* Fr.) Maire und *H. asierophorus* (Tul.), die jetzt *Pyxidophora Nectulidis* Brefeld heisst. Das Vorkommen der Chlamydospore ist also so überwiegend, dass es gegenüber *Nectria* Beachtung verdient.

Auch *Nectria rubi*, das Weese (1912) als Varietät von *N. mammoides* Phil. et Plowr. ansieht, ist nichts anders als eine *Hypomyces* in dem erwähnten Sinne. Wenn wir noch eine andere (App. & Wr. Grundlagen, 1910, p. 10) auf Kartoffelknolle gewachsene von Pethybridge, Dublin, entdeckte, dann von Berthold als *Hypomyces* bestimmte und hernach von mir studierte Schlauchform zum Vergleiche heranziehen, so erscheint diese Komplex recht einheitlich. Viele besitzen echte terminale Chlamydosporen, die in Wasserkulturen der Konidien schon nach 14 Tagen zu erzwingen sind. Andere haben Sclerotien. Es unterliegt keinem Zweifel, dass wir die *Nectriaceen* am besten in Sectionen und Gattungen gruppieren, wenn wir die Konidien, Chlamydosporen und sklerotialen Stromata genau auf Konstanz der Form und des Auftretens untersuchen. *Nectria cinnabarina* hat, wie auch Weese fand, an Sphaerostilbe erinnernde Stromata. Diese werden sehr gross auf solchen vegetabilischen Organen, die der Ausbildung der Plectenchyme günstig sind, und wenn man Mycel einer Reinkultur des Pilzes auf frisches Substrat überträgt. Echte Chlamydosporen und septierte Konidien fehlen dieser Art, und auch ihren Verwandten *N. oropensoides* (Rehm) Bref., *N. peziza* Tode und *N. lichenicola* (Ces.), mit denen sie vielleicht eine Section bilden, die ich *Tuberculariastrum* nennen möchte. *Nectria moschata* Glück hat nach Glück (1902) keine echten Terminal-Chlamydosporen, wohl aber intercalare, die er Gemmen nennt. Brefeld hat in seinen Studien wohl bei *Hypomyces* echte Chlamydosporen gefunden, bei den echten *Nectrien* aber nicht. Bei *Nectria cucurbitula* (Tode) Fr. fand er Gemmen, über deren Chlamydosporennatur er sich indes nur vorsichtig äussert. Bei *Calonectria graminicola* (Berk. et Brm.) Wr. (1913) und *Mycosphaerella solani*, welche Pilze verwandte Perithezien haben, sind sklerotiale Plectenchyme ausgebildet (Tafel XXII, Fig. 32 und 33), die oft auch als Stroma dienen. Sie ähneln in der Entstehung den Gemmen, d. h., intercalaren Chlamydosporen. Als solche werden sie auch oft, aber wohl mit Unrecht, interpretiert. Echte Chlamydosporen fehlen ihnen gänzlich. Ähnlich steht es mit *Gibberella*, das je nach Substrat oft sklerotiale plectenchymatische Stromata von sphaerostilbeartigem Umfang, oder verschwindend kleine oder gar keine Plectenchyme entwickelt.

Überblicken wir das Ganze noch einmal, so sehen wir die Askomyceten sowohl nach Chlamydosporen, Gemmen, Sklerotien, Konidien und Perithezien in Gruppen zerfallen. Fassen wir Gruppen mit möglichst vielen gemeinsamen Merkmalen zusammen und stellen sie anderen gegenüber, so gewinnen wir die natürliche Grundlage zu einer Reform der Systematik. Es braucht kaum wiederholt zu werden, dass die hier angeregte Form der Gruppierung nur ein Schritt ist, der noch nicht gleich zum richtigen Ziele führen mag.

Was *Hypomyces* anbelangt, so sollte man versuchen, solche Formen mit terminalen Chlamydosporen in diese Gattung aufzunehmen, die auch sonst in der Konidiengestalt und der Schlauchform Gemeinsames haben. Sind die Unterschiede in der Konidiengestalt zu gross, wie bei *Hypomyces ipomoeae* und *H. rubi*, so ist eine Einteilung in Sectionen am Platze. Für *H. ipomoeae* könnte die Sectio *Pseudomartiella*, für *H. rubi* die Sectio *Ramulariella* aufgestellt werden, da die Konidien ersterer der *Fusarium*-Sectio *Martiella*, die letzterer der Gattung *Ramularia* am nächsten stehen. Die Entscheidung darüber, ob es ratsam ist, später den ganzen *Hypomyces*-Komplex als Untergattung wieder zu *Nectria* zu stellen, welche Möglichkeit schon Fries, der Gründer dieser Gattung, im Auge hatte, bleibt zukünftigen Studien vorbehalten. Eine Entscheidung über Maire's (1911) wertvolle Anregung, *Hypomyces*-Arten mit ellipsoidischen Ascosporen ohne Anhängsel als neue Gattung *Nectriopsis* zusammenzufassen, halte ich für verfrüht, solange nicht die Konidien und Chlamydosporen besser bekannt sind, die sie vielleicht in Sectionen wie *Pseudomartiella* und *Ramulariella* der Gattung *Hypomyces* weisen oder als *Nectria* charakterisieren.

Ähnliche Vorschläge sind für *Mycosphaerella* zu machen. Nach neueren Untersuchungen haben einige Arten ein *Ramularia*-, andere ein *Ascochyta*-stadium. *M. solani* (Ell. & Ev.), *M. fragariae* (Tul.) Lindl., die ich in Reinkultur genauer studiert habe, besitzen ersteres (Tafel XXII, Fig. 17 und 18), *M. pinodes* (Berk. et Blox.) Stone und *M. lethalis* Stone dagegen nach Stone (1912) und Vaughan (1913) letzteres Konidien-stadium.

Der Zusammenhang von *Ascochyta* und *Mycosphaerella*, den Tulane für *M. fragariae* vertrat, ist nicht immer bestätigt. Da er auch für *M. citrullina* Gross. strittig ist (Brooks & Price, 1913), so herrscht über ihn auch heute noch keine wünschenswerte Klarheit. Auch nicht über den Zusammenhang mit *Septoria*, der von Saccardo, Brefeld und Potebnia (1910) vertreten wird, von anderen Forschern aber nicht (Melhus, 1913).

Zu den berührten Verschiedenheiten treten solche im Ascus. Es gibt Arten mit 8 und solche mit 16 Ascosporen. Letztere sind nach Grove (1912) besser als *Diplosphaerella* gesondert zu stellen.

M. solani und *M. fragariae* habe ich hier absichtlich als Beispiele gewählt, weil ihr Konidienstadium sehr verschiedene Bildungsweise hat und jede

Art in eine besondere Section weist: *Ascochyta* könnte man für Arten mit Pycnosporen ähnlichen aber pycnidenlosen, *Septocylindrella* für solche mit septocylindrischen Kettenkonidien mit oft scharf vortretenden Scheitelnarben aufstellen.

Falls das Vorkommen mit einem echten *Ascochyta*-Stadium ausgerüsteter *Mycosphaerellen* sich bestätigt, könnten diese als *Pycnosphaerella* von den anderen getrennt werden.

Von *Mycosphaerella solani* ist bemerkenswert, dass die Peritheciumwand auf trockeneren Medien dünn-schichtig blieb, auf sehr feuchten succulenten Substraten dagegen sehr dick wurde. Auf letzteren fanden sich die Ascosporen noch nach einem halben Jahre im Perithecium vor, doch waren die Asci verschwunden. Ascosporen solcher feuchter Kulturen hatten gequollene Zellen, waren also in der Mitte eingeschnürt. Dies Stadium entspricht der Überreife. Bei plotzlicher Austrocknung erst werden die Sporen herausgepresst und sammeln sich dann auf der Oberfläche der Perithecieenkolonien an. Macht man Mikrotomschnitte durch Perithecieen solcher überwässerter Kulturen, so ist man überrascht über ihre Ähnlichkeit mit Pykniden. Man würde sie ohne Studium in allen Alterstadien und auf verschiedenen feuchten Substraten sicher für alte Pykniden halten können. Naturmaterial würde jedenfalls leicht zur Verwirrung führen, besonders da Konidien und Ascosporen bei einigen Arten grosse Ähnlichkeit haben, wie auch Brefeld bemerkt. Natürlich nur in gewissen Stadien. Im normalen Zustand einer Kultur (Tafel XXII, Fig. 18 und 19) hat die Unterscheidung keine Schwierigkeit.

Da auch auf gleichem Substrate mit verschiedenen Wassergaben eine verschiedene Dicke des Peridiums nicht nur bei *Mycosphaerella* (Tafel XXII, Fig. 21), sondern auch bei *Calonectria graminicola* (Berk. & Brn.) erzwungen werden kann, so bilden alte Exsiccata mit dickschaligen Peridien keinen so scharfen Gegensatz mehr zu solchen mit dünn-schaligen Peridien. Dieser Befund an Reinkulturen ist durch Exsiccatastudien bestätigt worden und für die Nomenclatur nicht ganz ohne Bedeutung.

Einfacher ist das Studium der Gattung *Nectria*, die schon besser bekannt ist. Vom rein morphologischen Standpunkte herrscht bei allen Nectrien der Sectio Willkommiiotes eine schöne Übereinstimmung in der allgemeinen cylindrischen Konidienform. In der Grösse aber weichen sie von einander ab (Tafel XXII, Fig. 2 und 8) ebenso in der Septierung, die in Hochkultur bei *Nectria discophora* eine überwiegend 7-fache ist, während bei *N. gulligena* die Quinquesepate vorherrscht. Die Konidienbasis ist abgeplattet oder schwach convex, auch bei *Cylindrocarpon mali*, dagegen gewölbt, ellipsoidisch bis gotisch spitzbogig bei *C. cylindroides* und *Hypomyces rubi*. Die Konidien in normalen Blütestadien oder, vom Standpunkte künstlicher Anzucht gesprochen, in normaler Hochkultur quellen besonders auf holzigen Sub-

straten, in Gestalt saulenförmiger Schleime hervor, welche Erscheinung am besten die im Prinzip kettige Bildungsweise veranschaulicht. Wären Saulenschleime ein Merkmal weniger Gruppen, so würde sich die Verwandtschaft von Willkommnotes mit Ramularia und Septocylindrium mehr aufdrängen als jetzt, wo in einigen Sectionen der Gattung Fusarium dieselbe Erscheinung auftritt. Dagegen fällt mit dem Nachweise dieses Merkmals bei Fusarium die Scheidewand gegen Microcera Desm., die bekanntlich kegelförmig oder fast stiftartig hervorragende Fruchtlager hat. Die Kegelformen der Lager entstanden in der Kultur aus ursprünglichen Säulen als secundäre Veränderungen durch Schrumpfung infolge Austrocknung, durch Verwaschung infolge Berieselung. Oft ist das kastanienbraune sklerotiale Stroma, das beliebig über die Substratoberfläche emporwachsen kann, an dem Aufbau der Säulen-Fruchtlager beteiligt. Je widerstandsfähiger aber die Bastschicht des Substrats gegen Erweiterung der von den Sporodochien benutzten Öffnungen ist, desto mehr beschränkt sich das stromatische Plectenchym auf endobiotische Wachstumsweise, in welchem Falle die epibiotischen Säulen allein aus Konidien bestehen. Diese Erscheinung ist am besten bei *Nectria discophora* zu beobachten. Auf Stücken der Äste oder Stengel von Erle, Baumwolle, Ahorn, Steinklee brechen innerhalb drei Wochen so viel Konidiensäulchen bis zu einem halben Centimeter Länge hervor, dass die Substrate stellenweise wie gespickt aussehen.

Die Abgrenzung von Pilzen mit septocylindrischen Konidien wie Ramularia gegen Pilze mit spindelig sichelförmigen pedicellaten Konidien der Gattung Fusarium ist leicht. Es giebt aber Fusarien ohne Fusszelle (Tafel XXI, Fig. Q-S) wie *F. udum* (Berk.) und Varietäten, die vorwiegend Bewohner der Saftflüsse von Bäumen sind. Beiläufig bemerkt; bilden solche Fusarien zusammen mit *F. aquaeductum* eine gute Section der Gattung, die ich **Eupionnotes** nenne wegen des Übergewichtes dieser Sporenverlagerung. Andere Fusarien wie *F. semitectum* (Tafel XXI, Fig. L) und *F. orthoceras* (Tafel XXI, Fig. M) haben kegelförmige Basalzellen, selten eine reduzierte Fussform. *F. trichothecioides* (Tafel XXI, Fig. P) kann die Fussform entwickeln, während ellipsoidisch abgerundete Konidien ohne Fussform oft vorherrschen. Auf letzteren Formen begründen Wilcox, Link und Pool (1913) in einer gründlichen Arbeit über Kartoffelfäule die angeblich neue Art *F. tuberosorum* Wile. et Lk., während ich sie im Einklang mit Orton und Jamieson für völlig identisch halte mit dem subnormalen Stadium von *F. trichothecioides* Wr. (Jamieson und Wollenweber, 1912).

Aus Stämmen verschiedener Herkunft habe ich bei *F. trichothecioides* durch Selection von Konidien wiederholt die Sporodochienform gezüchtet, die sich durch die Sichelform pedicellater Konidien auszeichnet. Die Tendenz dieses Pilzes in die Kommaform zurückzuschlagen, macht es aber

schwierig die Hochkultur konstant zu halten, falls man nicht mit allen Mitteln der Methodik ausgerüstet ist. Endlich sei noch *F. ventricosum* (Tafel XXI, K) erwähnt, die zwar in der Norm nur eine flüchtige Ähnlichkeit mit *Ramularia* hat, aber in Ankultur leichter von Anfängern mit solchen in Verbindung gebracht werden könnte.

II. RAMULARIA (UNGER) FRIES

Unger begründet 1833 *Ramularia* auf die beiden Arten *R. pusilla*, die er auf *Poa* und *R. didyma*, die er auf *Ranunculus*-Blättern fand, ohne eine Gattungsdiagnose zu geben. Diesem Mangel sucht Corda (1842) abzu- helfen, indem er mit *R. pusilla* als Typus folgenden Gattungsbegriff verbindet: Flocci entophyllini, repentes, continui, dein erumpentes. Sporae acrogenae, simplices; nucleo firmo. *R. didyma* dagegen tauft er um in *Didymaria Unger* Cda. (1854) und schafft für sie die Gattung *Didymaria*, die er wie folgt begrenzt: Flocci entophyllini, repentes, continui, sporis acrogenis, heterogeneis, didymis, dein inspersis. Wir sehen bereits bei *Fusarium*, dass Corda die Septierung überwertet und sich dadurch so festlegt, dass sein System nicht entwicklungsfähig blieb. Ebenso bei *Ramularia*. Unger verliel der Septierung nur Artwert, denn seine *R. pusilla* hat einzellige, *R. didyma* meist zweizellige, gelegentlich aber drei- bis vierzellige Konidien, die er Tab. 2, Fig. 10 abbildet. Als nun gar Bonorden (1851, p. 41 und 319) *Ramularia* für ein freies *Cacomma* erklärt und *R. pusilla* Ung. als *Cacomma pusillum* Bon. in diese Gattung überführt, büsst *Ramularia* scheinbar ihre Existenz ein. Gegen Bonorden's Standpunkt wendet sich mit Recht Fresenius (1863), der 5 *Ramularien* der Unger'schen Auffassung beschreibt, und daher Arten mit septierten Konidien einschliesst. Damit wendet er sich auch gegen Corda's verbesserte Diagnose für *Ramularia*, die nur einzellige Konidien anerkennt. Fresenius wurde jedenfalls in seiner Ansicht durch Fries (1849, p. 493) bestärkt, der inzwischen eine Diagnose der Gattung *Ramularia* gegeben hatte, die sich am weitesten Unger's freiem Standpunkt anpasst und die Septierung wieder freigibt: Flocci discreti, e mycelio repente (subentophyllo) surgentes, ramosi, vulgo septati. Sporae solitariae, terminales, septatae. Fresenius fügt aber ein neues Gattungsmerkmal hinzu, indem er Arten wie *R. urticae* Cesat. zu *Ramularia* zieht, deren Konidien kettenartig verklebt bleiben können und eine deutliche Scheitelnarbe haben. Daher ist Fresenius verantwortlich für die Tatsache, dass heute Arten wie *R. Tulasnei* Sacc. in der Gattung bestehen. Ich vermute nämlich, dass solche Arten zu *Mycosphaerella* gehören, während andere vom Typus der *R. didyma* Unger (non Fresenius) und *R. macrospora* Fres. echte *Ramularien* sind. Da *R. didyma* Ung. aber wegen unvollständiger Beschreibung eine Sammel-species geworden ist, wird sie am

besten gestrichen, doch liegt damit kein Grund vor die Gattung zu streichen, die nach Unger's Arten von Fries begrenzt wurde. Saccardo (188), p. 20) macht einen neuen Versuch, die Septierung der Konidien einzuschränken, indem er *Ramularia* so fasst: *Biophila*. *Hyphae* breve vage ramulo-ae; conidia ovato-cylindracea, varia, denique 2-pluriseptata (et interdum catenulata). Exempli: *R. urticae* Ces., *R. cynarae* Sacc. Diese Ausschliessung ein- bis zweizelliger Arten aus der Gattung kann man aber deswegen nicht gutheissen, weil sie in Unger's Arten gar nicht ausgedrückt ist. Auch stösst, man wie Lindau (1905, p. 431) hervorhebt, auf die grössten Schwierigkeiten durch die Tatsache, dass subnormale und junge Konidien ein- bis zweizellig sind, ältere ausgereifte dagegen mehrzellig. Kriterien der Norm aus Naturmaterial allein abzuleiten, ist aber bedenklich, da man einer kleinen Spore nicht ansieht, ob die später grösser und höher septiert werden würde. Damit soll nicht gesagt sein dass *Didymaria* Corda und *Ovularia* Sacc. (1880, p. 17), die subnormalen *Ramularien* ähneln, tatsächlich zu *Ramularia* gehören müssen. *Didymaria helvellae* Cla. gilt beispielsweise heute als *Didymopsis helvellae* (Cda) Sacc. et March. Aber es ist unnatürlich Arten mit nur zweizelligen Konidien zu *Didymaria* zu stellen, wenn sie in allen anderen Merkmalen mit *Ramularia* (Unger) Fries übereinstimmen.

Es scheint also am besten zu dem Unger'schen Standpunkt zurückzukehren und die Fries'sche Diagnose für *Ramularia* anzuerkennen, aber auch auf weniger als 2-septierte Formen auszudehnen. Auch Fresenius' Stellung passt sich an, ausgenommen vielleicht Arten mit Scheitelnarben der Konidien. Solche gehören aber wie beispielsweise *Ramularia Tulasnei* Sacc. zu *Mycosphaerella* und werden daher vielleicht ohnehin allmählich ausscheiden.

Bei der im systematischen Teile gegebenen erweiterten Diagnose ist insbesondere das Vorkommen von Chlamydosporen als neuer Gattungscharakter hervorzuheben.

Zwischen *Ramularia* und *Fusarium* bestehen Berührungspunkte. *Ramularien* haben allgemein cylinderförmige Konidien, *Fusarien* dagegen nicht. Dagegen ist beiden Gruppen die Eigenschaft gemeinsam, die Konidien eine hinter der anderen an derselben Stelle kettenförmig abzuschneiden. Hunderte von Ketten eines Sporodochiums verkleben oft zu Säulehen, die aus dem Substrate hervorquellend, diesem senkrecht aufgesetzt scheinen. Beide erwähnten Gruppen haben Arten mit und ohne Schlauchform. Aus einigen *Ramularia*-artigen Pilzen entwickelte sich *Mycosphaerella*. Solche *Ramularien* hatten keine Chlamydosporen. Andere bildeten leicht Konidien und Chlamydosporen, während die Schlauchform nicht erschien. (Ausnahme *Hypomyces rubi*). Ganz parallel verliefen Versuche mit anderen Sectionen. Der Unterschied lag nur darin, dass die Schlauchform hier stets

zu *Neetria* gehörte. Im allgemeinen tritt also die *Chlamydospore* als Ersatz für die fehlende Schlauchform auf. Genau so liegen die Verhältnisse bei der Section *Discolor* des Genus *Fusarium* und *Gibberella*.

Eine bessere Kenntnis und Umgrenzung der Nachbargattungen von *Ramularia*, wie *Hormiaetis*, *Isariopsis*, und *Acrotheca* tut not, auch der Gattung *Microcera* und vor allem *Bactridium*, das sehr heterogene Elemente umfasst.

Isariopsis ist möglicherweise nichts als eine *Ramularia*, deren Konidien an Koremien abgeschnürt werden, *Hormiaetis* eine *Ramularia* mit nur 1-septierten Kettenkonidien, *Acrotheca solani* Sacc. eine vorherrschend einzellige *Ramularia*. Merkmale wie Koremien, Konidienverkettungen und Septierung können aber von Ausnahmen abgesehen, nicht gattungstrennende Bedeutung haben. Das scheint ebenso sicher, wie die Tatsache, dass das Stroma ohne grosse Bedeutung für die generische Abgrenzung ist. Bei einem Vergleich mit *Septocylindrium* fiel es auf, dass abgesehen von einer durchschnittlich höheren Septierung kein Unterschied gegen *Ramularia* besteht. Da auch die Septierung nur Artwert hat, sind diese Gattungen sicher miteinander zu vereinigen.

Da die 6 *Ramularien* dieser Arbeit überwiegend von Kartoffelknollen stammen, konnte man erwarten, eine von ihnen in der bisherigen Literatur über Kartoffel schon erwähnt zu finden, wenn auch unter anderem Gattungsnamen. Eine Durchsicht der Arbeiten bestätigte das. Harting (1846) gibt Tafel II, Fig. 2 und 4, gute Abbildungen des Pilzes *Fusisporium didymum* mit den Characteren "floccis sterilibus decumbentibus dense intertextis, infimis fuscis superis albis, fertilibus albis tenerrimis erectis ramosis parce septatis ramis erecto—patentibus, sporidiis terminalibus concoloribus vix arcuatis obtusatis bisepatis" und fügt auch die Länge der Konidien, 25-33 μ hinzu. Unter "bisepatis" versteht er im Einklang mit den Zeichnungen zweikammerig, also 1-septiert. Dieser Pilz hat die wesentlichen Merkmale einer unserer *Ramularien*. Um diese aber nicht mit *Ramularia didyma* Unger (1833) verwechseln zu können, die zwar jetzt *Didymaria Ungerii* genannt wird, sei der Name *R. eudidyma* vorgeschlagen. Der spärlicheren Verzweigung der Konidienträger dieser Art und der *R. macrospora* (Tafel XX, Fig. A) steht die wiederholt wirtelige, büschelige Verzweigung bei *R. candida* (Tafel XX, Fig. C und D) gegenüber, doch finde ich neuerdings, dass dieses Merkmal nicht sehr wertvoll ist. Auch *R. macrospora* kann sich zu wirteliger Verzweigung erheben. Leider konnte die Abbildung einer solchen nicht mehr Platz finden. Bei *Ramularia anchusae* und *R. Magnusiana* (Tafel XX, Fig. C) ist die Dauerverkettung der Konidien häufiger auch im Wasser mikroskopisch beobachtet worden, bei den andern nur makroskopisch. Die Septierung, Grösse (Tafel XX, Fig. A und C), Häufigkeit und Verlagerung von Konidien und *Chlamydosporen* (Tafel XX, Fig. B und E),

liefern eine Reihe mehr oder minder wichtiger Merkmale der Artunterscheidung (Vgl. die Tabelle der Grösse und Septierung).

Anomalien wie Quellungen der Konidienzellen bei verzögerter Keimung (Tafel XX, Fig. II) lassen vermuten, in welcher Weise Arten wie *Fusarium constrictum* Penz. zu deuten sind. Es wäre denkbar, dass solche zu *Ramularia* gehören. Andere bisher *Fusarium* genannte Pilze besitzen so ausgeprägt cylindrische Konidien, dass sie gewiss Ramularien sind, andere besitzen ovale Konidien, so dass sie ebenfalls aus der Gattung *Fusarium* ausscheiden müssen. Solche zweifelhafte Formen finden sich bei Lindau's Zusammenstellung in Rabenhorst's Kryptogamenflora unter den Namen: *Fusarium Bagnisianum* (v. Thüm.), *F. platanoide*s (Oud.), vielleicht auch *F. pandani* (Cda), *F. lagenariae* (v. Schwein.), *F. Tuberis* (Preuss), *F. georginae* (Cda), die teils *Ramularia*, teils anderen Pilzen angehören. Bei *R. eulidyma*, fällt eine gewisse Dorsiventralität des Scheitels der Konidie auf; dieselbe ist oft unmerklich bei der schmalen candida (Tafel XXI, Fig. C und Tafel XXI, Fig. B). Arten wie *F. minutissimum* sind bereits zu *Ramularia* gestellt worden nach v. Höhnelt.

Ramularia olida, n. sp. Diese Art verdient wegen ihrer Ausnahmestellung mehr Beachtung. Sie ist die einzige der 6 *Ramularien*, die sich schon von weitem durch einen starken, fast beläuhenden, widrigen Erdgeruch bemerkbar macht und bei der das Stroma nicht kastanienbraun wird. Das Farbenbild ist also das denkbar einfachste, indem es sich auf buttermilchig bis creme beschränkt. Diese Farben nehmen im Mycel alle Aufhellungsgrade bis nahezu weiss an als Konidienfarbe, in plectenchymatischer Form hingegen tiefere Töne bis zu einem Chromgelb. Kontrastfarben fehlen gänzlich, falls man nicht bräunliche Trübungen harzig eingetrockneter Konidienmassen also solche auffassen will. Die Art ist kaum mit irgend einer anderen zu verwechseln. Sie ist bisher nur einmal gefunden worden, nämlich auf einer verwundeten Kartoffelknolle (Sorte, "Böhms Erfolg," Oktober 1910, Rittergut Neuhauss, Selchow bei Berlin), in einem auf freiem Felde zur Einnischung aufgeschütteten Haufen. Die Ernte war sehr gross und die Knollen gesund, so dass von einer grösseren Schädigung durch diesen Pilz am Fundorte nicht die Rede sein konnte. Infektionsversuche mit Reinkulturen des Pilzes fielen in einigen Fällen positiv, in den meisten aber negativ aus. Zum Schlusse sei unter Hinweis auf Tafel XX die Beständigkeit der Konidienform (Tafel XX, Fig. K), die paarige Verästelung jugendlicher Träger (Tafel XX, Fig. M) und hohe Wirtelung ausgewachsener Trägerstände der Sporodochien (Tafel XX, Fig. L) hervorgehoben. Auch die reichliche Bildung besonders 2-zelliger Chlamydosporen (Tafel XX, Fig. J) ist bemerkenswert. Ein Mikrokonidienstadium fehlt. Die Art gebrauchte längere Zeit zur Anpassung an künstliche, sterilisierte Substrate als andere Species. Auch in dieser Zeit der Ankultur fanden sich nur einige niedrig

septierte Konidien im Luftmycel vor. Der Erdgeruch war schon vorhanden, wurde aber stärker in der Normkultur, um so stärker, je mehr die Konidienmengen gesteigert wurden und das Mycel zurücktrat, aber nicht auf beliebigen Substraten, sondern auf Milch, Reis, Mais, mehr als auf Kartoffelknolle, auf dieser aber wieder mehr als auf Hölzern oder Stengeln. Mit anderen Worten die Entwicklung von Erdgeruch stieg mit dem Proteingehalt der Substrate.

III. HYPOMYCES

Hypomyces rubi (Osterw.) n.n.

Der Konidiengestalt (Tafel XXII, Fig. 15) nach haben wir bei flüchtiger Betrachtung fast *Ramularia olida* (Tafel XX, Fig. N) vor uns, doch finden sich feinere Unterschiede: Stärkere Krümmung der idealen Längsaxe, gelegentlich schwache Neigung zu keulenartiger Anschwellung. Solche Formen sind nicht gezeichnet, da sie nicht die Regel sind. Die Septierung von *H. rubi* liegt tiefer als die von *R. olida*; Quinquesepaten sind selten. Wichtig ist das Merkmal eines sehr beständigen tief rotvioletten Mycelfarbstoffes, der auch die Konidien durchdringt. Die Gattung *Hypomyces* ist reich an lebhaften Farben. Die Schlauchform trat in künstlichen Reinkulturen Osterwalders ebensowenig auf wie in den meinigen bis jetzt, dagegen auf den in die feuchte Kammer gebrachten kranken Himbeerwurzeln. Die Zugehörigkeit einer *Fusarium*generation zu der Schlauchform wies Osterwalder einwandfrei nach in Folgekulturen einer Ascospore. Solche Folgekulturen bezog Verfasser aus Amsterdam.

Über die Natur des Pilzes liegen entscheidende Infektionsresultate noch nicht vor.

Auffallender Weise hat nun Osterwalder von weissen Sporodochien, die auf den Himbeerwurzeln mit den gefärbten assoziiert waren, noch eine zweite *Fusarien*form isoliert, die kein Violettrot bildete auf denselben Substraten, auf denen das *Nectria-Fusarium* es regelmässig tat. Auch bildete sie normal viel kleinere Konidien, die aber unter abnormen Verhältnissen auch beim *Nectria-Fusarium* vorkommen können. Diese Unterschiede bewertet Osterwalder nicht hoch, sondern zieht sie in den Variationskreis seiner Art. Er kombiniert also den blassen Stamm mit dem violettroten. Ich kann ihm darin nicht folgen, nachdem ich beide aus Amsterdam erhaltenen Serien verglichen habe. Morphologisch und biologisch sind wesentliche Unterschiede zu finden, was am klarsten aus meiner Bestimmung des blassen Stammes als *Ramularia ewigiyama* (Hart) hervorgeht.

IV. CYLINDROCARPON

Cylindrocarpon cylindroides n. sp.

Diese Art ist nur einmal isoliert worden. Die weisslichen Sporodochien bedeckten die absterbenden zweige von *Abies concolor* var. *violacea*. Die stammten aus eine Baumschule des Kreises Pinneberg, Holstein, Juli 1910, wo der Pilz seit Jahren Bestände 2-3 m hoher Pröpflinge vernichtete, während er Sämlinge nicht befiel. Das Mycel wächst leicht in Zonen und hat einen zarten Seidenglanz. Eine Pionnotes, deren Entstehung, z.B. auf gekochter Kartoffelknolle und auf Reis verfolgt werden kann, zeigt die Art sporenwilliger als *C. mali*, doch erhebt sich die Septierung bei der Pionnotes ebenso wenig zur Norm wie bei der Vergleichsart. Normalc, 3-5-septierte Konidien, die gerader als bei anderen *Cylindrocarpon* sind, entstehen in Säulchen auf sterilisierten feuchten Hölzern z.B. von Erle und Apfel. Der gotische Spitzbogen der Basis des Konidienlängsschnitts ist ebenso auffällig wie bei *R. olida*. In seltenen Fällen wurde bei beiden Arten eine Neigung zur Bildung einer Ansatzpapille beobachtet. Das Plectenchym tritt weniger stark hervor als bei *C. mali*; es wurde auf Reis gesehen, nicht auf Kartoffelknolle; die Farbe ist nicht auffällig rotbraun. Bei *C. cylindroides* machte sich der Vorteil der künstlichen Anzucht vor der Bestimmung nach Naturmaterial bemerkbar. Nach letzterem konnte man geneigt sein, die stärkere Streckung, geringere Septierung und Breite der Konidie als Variabilität zu deuten; übersah man dann noch die spitzbogigen Schlusscurven der Konidien, so fiel die Art mit *C. Mali* zusammen, während in der Tat sowohl morphologische als biologische Merkmale dieser Art eine besondere Stellung geben.

Der Nachweis von Peritheccien steht indes noch aus, doch ist im Einklang mit Laubert's Vermutung zu erwarten, dass *Nectria cucurbitula* (Tode) Fr. die Schlauchform dieses Pilzes ist, da diese auf Nadelholzern verbreitet, wenn nicht darauf beschränkt ist.

V. NECTRIA

Nectria discophora Mont.

Frau van Hall-de Jonge (1910) hat diese *Nectria* häufig an von Stammkrebs befallenen Kakaobäumen gefunden und deren Entwicklungsgang aufgeklärt. Sie nennt den Pilz *N. striatospora*. Zwar findet sie die Ascosporen etwas grösser als Zimmermann bei seiner *N. striatospora* (Centralblatt für Bakt. u. Paras., 2. Abt., 7: 105. 1901), hält den Unterschied aber nicht für wichtig genug, um eine Sonderstellung des Pilzes zu rechtfertigen. Weese und v. Höhnelt wiesen dann die in der Diagnose nachzulesende Sy-

nonymik nach. Es gelang de Jonge, die Konidienform sowohl direkt aus Ascosporen als auch an kurzen Trägern keimender Mutterkonidien zu züchten. Da sowohl Zimmermann als auch de Jonge die Art als Saprophyt ansahen, [was ich nach erfolglosen Impfungen an Cacaobäumchen bestätigen kann, war für mich nur noch der Züchtungsversuch von Perithezien von Interesse. Reinkulturen des Pilzes waren von dem Phytopathologischen Institute in Amsterdam zu beziehen. Da dort immer nur das Konidienstadium, nie die Schlauchform aufgetreten war, versuchte ich ein geeigneteres Substrat zu finden. Zunächst erwies sich das Verfahren erfolgreich, mit dem sich Perithezien von *Nectria galligena* aus Konidien hatten züchten lassen. Kartoffelstengel mit einer normal gereiften Konidiengeneration wurden nach allmählicher Austrocknung in 6 Monaten mit Wasser übergossen, worauf in der Tat in vier Wochen reife Perithezien zum Vorschein kamen. Dies Ergebnis ermutigte zu weiteren Studien, die mit einzelnen Ascosporen auf demselben Substrate, auch ohne vorherige Austrocknung zum Ziele führten. Anstatt Kartoffelstengel wurden ferner Lupinestengel gewählt, auf denen die Zahl der Perithezien schon etwas höher wurde. Doch erschienen sie mehr einzeln als in Gruppen. Auf Kartoffelknolle wuchs einmal ein erbsendickes Stroma mit gegen 100 Perithezien hervor. Viel besser aber erwiesen sich holzige Substrate, mehrjährige Apfel-, Eichen- und Buchenäste, die gelegentlich auch lebend (nach Formalindesinfektion äusserlich) verwendet wurden und auf denen einige schöne Kolonien auftraten. Alle genannten Nährböden aber übertraf bei weitem Alnus, deren ausgereifte Zweige, in jeder Dicke verwendet, stets im Licht nach drei Wochen mit Kolonien der Schlauchform übersät waren, wobei es gleichgültig war, ob reife Konidien oder Ascosporen als Ausgangspunkt gewählt waren. Wichtig waren aber einerseits das Licht und andererseits die Abstimmung der Feuchtigkeit. Wasser im Überschuss hemmt die Ausbildung normaler Entwicklungsformen. Diese Erfahrung gilt für alle Fusarien und deren Schlauchform. Selbstverständlich ist eine gewisse Feuchtigkeit nicht zu entbehren. Ist das Holz mit Wasser gesättigt und soviel Wasser im Überschuss hinzugefügt, wie in drei Wochen verdunstet, so ist der Erfolg sicher bei normaler Temperatur. Die Jahreszeit spielt nicht die geringste Rolle. Selbstverständlich aber giebt es einen Thermo- und Phototonus, deren Überschreitung eine Störung der Lebenskraft zur Folge hat und Lücken im Entwicklungskreise herbeiführt. Die Kardinalpunkte sind aber nicht festgestellt.

Unter Hinweis auf die Arbeit van Hall-de Jonge's und einige Abbildungen sowie die Messbelege und Diagnose am Schlusse, kann ich mich auf wenige ergänzende Bemerkungen beschränken. Das Stroma war in seiner Ausdehnung ganz eine Funktion des Substrats. Auf holzigem behüllten Substrate blieb es um so kleiner, je trockener und fester die Hülle war. Sehr

stark aber entwickelte sich das Stroma auf stärkehaltigem Substrat, Weizen, Reis, auf denen es, nebenbei gesagt, zu reicher Konidienbildung (oft Pionnotes) kam. Auf Kartoffelknolle war das Gesamtwachstum des Pilzes schwächer. Auf Lupine trat das pleotenchymatische Stroma manchmal über die Epidermis empor und bildete nach einem künstlichen Regengüsse Perithezien. Ich bin danach, wie ich schon oft erwähnt habe, mit Erw. F. Smith, v. Höhnelt und Weese völlig einverstanden darin, dass das Stroma als Merkmal in vielen Zweigen der Systematik weit überschätzt worden ist. Es ist bedauerlich, dass der Wert sonst guter und mühevoller Arbeiten über Ascomyceten durch Benutzung des Stromas als Scheidemerkmale für Untersuchungen bei *Nectria* vermindert wird. Das Studium auch nur weniger *Nectriaceen* in künstlicher Reinkultur wird Fehler dieser Art ausschliessen. *Nectria discophora* ist sehr geeignet zu solchen Studien, aber auch *Hypomyces ipomoeae* und *Gibberella Saubinetii*. Besonders interessant ist *N. discophora* durch die Fülle säulenförmig hervorquellender Konidien, die stets vor und oft noch während der Perithezienbildung auftreten. Die Konidie als solche ist wegen ihrer Grösse zu cytologischen Untersuchungen besonders geeignet. Die Ascosporen sind ebenfalls gross und gestatten ein Studium der festen Netzstruktur (Tafel XXII, Fig. 10) des dicken Episporiums im Mikrotom-Längsschnitt und das der runzeligen, oft in spiralig gedrehten anastomosierenden Meridianriefen verlaufenden Oberflächenstruktur, die die Netzstruktur nach aussen abschliesst.

Nectria galligena Bres.

Wichtige Aufklärungen über die mit *N. galligena* oft verwechselte Sammelart *Nectria ditissima* Tul. verdanken wir Seaver (1909) und v. Höhnelt und Weese (1911). Ich halte mich an die letzte Arbeit.

Diese tritt im Einklang mit Seaver (z. T.) und v. Höhnelt die Ansicht, dass *Nectria ditissima* der älteren *N. coccinea* (Pers.) Fries (= *Sphaeria coccinea* Persoon) synonym, inzwischen aber vielfach als Pseudonym für *N. galligena* Bres. gesetzt worden sei (Aderhold, Appel & Wr.¹); dass diese letztere den wahren Krebs an Laubhölzern verursache, *N. coccinea* aber nicht. Das Beweismaterial sind ausser Literaturangaben noch Originalexemplare von Exsiccaten und sorgfältige Vergleiche mit frischem Material. Einwände gegen diese nicht durch künstliche Reinkultur gesicherte Beweisführung zu erheben, ist hier überflüssig, da die durch ein so eingehendes Ver-

¹ Ich füge noch Brefeld (1891) an, der *N. ditissima* und *coccinea* für kaum unterscheidbar hält und letztere mit Ascosporen von der Grösse der *Galligena*-Sporen abbildet, sodass er *N. galligena* anstatt obiger beider beschrieben hat. Beide fanden sich auf Buche, erstere in Verbindung mit krebzigem Zerfall der Rinde, letztere nicht. So giebt schon Brefeld indirekt Anhaltspunkte für das Vorkommen von *Nectria galligena* auch auf krebziger Buchenrinde.

gleichstudium gewonnene Erfahrung für die Richtigkeit der Bestimmungen bürgt. Doch ist im allgemeinen vor einer Überschätzung der Exsiccate zu warnen, da immerhin damit zu rechnen ist, dass Originalexsiccate, die allmählich vielen Forschern durch die Hand gehen, bei Vergleichstudien versehentlich mit anderen vertauscht werden. Neuere Sammlungen, deren Originalstücke durch Photographie vor Verwechslung geschützt werden, bieten damit eine Bürgschaft für Echtheit; auch alte sind häufig durch Zeichnungen und handschriftliche Bemerkungen gesichert. Fehlen aber solche, und sind die Beschreibungen der Pilze obendrein ungenau, so wird eine Verwechslung der Originalstücke lange verborgen bleiben und später eine Quelle der Verwirrung werden können. Aber selbst wenn sie echt sind, ist ihr Wert nicht so gross, wie viele annehmen. Das zeigt das bisher unbekannte Vorkommen von *N. galligena* auf Buche ohne Begleitung krebsigen Rindenzerfalls. Die Perithezien lieferten aber Reinkulturen von Konidien, mit denen dann von künstlichen Wunden aus Rindenkrebs bei Gravensteiner und Englischen Winter Goldparmaine Apfelhochstämmen in Dahlem hervorgerufen werden konnte. Wunden ohne Impfung verheilten glatt. Gleichzeitig vorgenommene Inoculationen mit Konidien der *Kakaonectria*, *N. discophora* Mont., verliefen negativ, auch solche mit *Cylindrocarpon cylindroides*. Dagegen ergaben Impfungen mit Konidien von *C. mali* und von Apfelkrebsen verschiedener Provenienz mehr oder weniger progressive Krebsstellen.

Diagnose und Tafelabbildungen 1-6 der Schlauchform liegen Reinkulturen auf sterilisierten Kartoffelstengeln zugrunde. Nur wenige Peritheciengruppen waren vorhanden, im ganzen auf zwei Stengeln fünf Stück. Form und Grösse von Perithezien und Ascosporen waren typisch, wie Vergleiche mit dem Originalstück von Buche bewiesen. Die Abbildung des Peritheciums ist mehr der Struktur als der Form wegen gegeben. (Tafel XXII, 6) das Perithecium stand zwischen anderen eingezwängt und war länglich, während der Durchschnitt konisch, subkonisch bis eiförmig ist, und kleine sogar der kugligen Form nahekomen. Die mehr rundliche Form deutet wohl nicht auf eine besondere Varietät, denn sie fand sich auch häufig an Naturmaterial von Apfelkrebs (Sorte Kaiser Alexander) aus der Sammlung der Biologischen Anstalt, bei dem indes die Ascosporengrössen wie auch die übrige Morphologie mit *Nectria galligena* übereinstimmten. Dieses wie auch das Originalstück von Buche sind von Dr. Laubert gesammelt worden. Neu an vorliegender Darstellung ist der Nachweis von *Nectria galligena* auf Buche der Nachweis ihrer Konidienform und die Erregung von Apfelkrebs durch sie. Appel und Wollenweber (Kultur als Grundlage. . . . 1910, S. 448) erwähnen die Art noch unter dem Namen *N. ditissima*. Morphologie und Abbildung der Konidienform beziehen sich auf Folgekulturen von Ascosporen der Kartoffelstengel-Perithezien. Die Belege der Durch-

schnittsausmasse der Septaten befinden sich in der Tabelle am Schlusse. Das Mycel hat auf Reis eine schwach zitronengelbe Färbung.

VI. PATHOLOGISCHE STUDIEN

Soweit sich die pathologischen Daten, die zur Stütze der Identität gelegentlich erwünscht waren, auf *Ramularia*-Pilze beziehen, hat Fräulein Clara Hasse einen grossen Teil der Impfungen und Reisolationen in bereitwilliger Weise übernommen, wodurch die vorwiegend systematisch angelegten Studien zu einem schnelleren Abschlusse geführt worden sind. Fräulein Hasse hat dadurch als erste den Nachweis erbracht, dass *Ramularia* und zwar *R. macrospora* Fres. eine Apfelfäule hervorruft. Kurz darauf sind Charles Brooks und Fischer unabhängig von uns zu demselben Ergebnisse gekommen mit dem von einem Apfel anderer Herkunft isolierten gleichen Pilze. Da die von Kartoffel isolierte deutsche, englische und amerikanische *R. macrospora* meiner Sammlung dieselben pathogenen Eigenschaften zeigten wie der Apfelpilz, besonders in Folgeversuchen mit reisolierten Pilzen des ersten Versuchs, so ist die Identität dieser, die ich auf Grund der gleichen Morphologie bereits vertreten hatte, gut gestützt. Dem pathogenen Verhalten der *Ramularia macrospora* steht gegenüber die gänzliche Unschädlichkeit von *R. olida*. Auch *Hypomyces rubi* konnte reife Äpfel von Wunden aus nicht angreifen. Versuche mit *R. candida* und *R. anchusae* verliefen ebenfalls negativ, während *R. eudidyma* und *R. Magnusiana* eine langsame Fäulnis verursachten, die aber weder besonders gleichmässig noch so schnell vorwärtsschritt wie die durch *R. macrospora* erzielte. Da endlich auch von Humus und faulenden Pflanzenteilen verschiedener Herkunft isolierte Stämme morphologisch und pathologisch sich *R. macrospora* gleich verhielten, konnte Fresenius' Art mit allen identifiziert werden.

Um endlich zu prüfen, ob die mit blattfleckenbildenden Pilzen identifizierten Stämme heliobiger Herkunft auch Blattflecken bildeten, wurden teils auf lebende, teils auf sterilisierte Blätter Sporenaufschwemmungen übertragen. Es stellte sich in der Tat in vielen Fällen heraus, dass die Absterbeerscheinungen lebender beimpfter Blätter zu ähnlichen Bildern führten, wie die Exsiccate der verglichenen Species sie aufweisen. Auf *Ranunculus*, *Campanula* und anderen Kräutern finden sich nebenbei bemerkt eine ganze Reihe Blattfleckenbewoner, die mit Fusarien und anderen Pilzen vergesellschaftet sein können. Damit war ein Zweck dieser Schrift erfüllt nämlich der, einige *Ramularien* als Ubiquisten nachzuweisen. Bezüglich Einzelheiten verweise ich noch auf den systematischen Teil dieser Arbeit.

Es war für mich ferner von Interesse, die Verbreitung des europäischen Krebses der Obst- und Laubholzbäume festzustellen. Der Erreger, früher oft *Nectria ditissima* genannt, hat, wie Weese (1911) feststellte, *N. galligena*

Bres. zu heissen. Da ich denselben seit 1910 in Reinkultur in allen Entwicklungsstadien (Tafel XX, Fig. 1-6) besass, war es leicht, die hiesigen Exsiccate auf eine Identität mit diesem Pilze hin abzusuchen. Es gelang mir aber nur in einem Falle, den Pilz in der Sammlung auf amerikanischem Holz zu finden. Diese *N. galligena* war von W. B. Taylor 1913 in Plymouth, Massachusetts, auf Apfelkrebs gesammelt und von O'Gara als *N. mammoidea* Plowr. bestimmt worden. Durch die Richtigstellung dieses Exsiccate wurde zum ersten Male der europäische *N. galligena*-Apfelkrebs in Amerika sicher nachgewiesen. Da dieses Material auch normale Konidien aufwies, so ist ein Zweifel an der Identität nicht möglich. Dieser Apfelkrebspilz scheint aber, soweit wir wissen, in Amerika selten zu sein und, wenn überhaupt, nur in den nördlichen Staaten und Kanada Entwicklungsbedingungen ähnlich denen Europas zu finden. Zwar ist er hin und wieder auch in Jahresberichten südlicher Staaten der Union aufgenannt, wo er in hochgelegenen Gegenden natürlich vorkommen könnte, aber die Exsiccate, die unter dem bisherigen falschen Namen des Krebserregers, *N. ditissima*, gehen, lassen keine Identität mit *N. galligena* zu, sodass dieser Pilz in der Tat erst einige Jahrzehnte im Lande sein mag. Sollte sich diese Vermutung bestätigen und er auch nicht auf anderen Wirtspflanzen gefunden werden, so ist ein wirksamer vorbeugender Schutz des amerikanischen Obstbaues durch scharfe Kontrolle bei der Einfuhr europäischer Sorten jetzt noch möglich. Ich halte es für bemerkenswert hinzuzufügen, dass ein fast mit *Nectria galligena* identischer Konidienpilz (Tafel XXI, Fig. G) von mir in Berlin aus dem Endocarp eines Apfels isoliert worden ist. Da dieser Pilz Perithezien bisher nicht gebildet hat, habe ich ihn vorläufig *Cylindrocarpon mali* genannt und glaube, dass er mit *Fusarium mali* Allescher identisch ist. Dieser Endocarpilz erzeugte in künstlichen Impfversuchen ebenfalls Apfelstammkrebs, aber nicht Apfelfruchtfäule, sodass das Fruchendocarp nur ein Überwinterungsort des Krebserregers ist. Damit ist aber bewiesen, dass diese Krankheit auch durch die Früchte übertragen werden kann. Von dem genannten Pilze des Krebses der Laubholzbäume ist der Erreger des Nadelholzkrebses, *Nectria cucurbitula* (Tode) Fr., verschieden. Den mutmasslichen Konidienzustand dieses Pilzes habe ich von *Abies concolor* var. *violacea* isoliert, dessen Zweige er offenbar abgetötet hatte. Da Perithezien mit ihm nicht vergesellschaftet waren und in Reinkultur noch nicht aufgetreten sind, nenne ich ihn vorläufig *Cylindrocarpon cylindroides* n. sp. Ursprünglich glaubte ich ihn identisch mit *N. galligena*, habe mich aber überzeugt, dass seine Konidien (Tafel XXI, Fig. F) subdorsiventral sind, während die der Vergleichsart (Tafel XXI, Fig. H) ausgeprägt cylindrisch oder etwas keulig sind. An die Morphologie dieser Pilze ist die einiger Verwandter angeschlossen, wobei der Entwicklungsgang so genau wie möglich verfolgt und dargestellt ist. Die systematische Gruppierung, die von

dieser immerhin geringen Anzahl Arten abgeleitet ist, teile ich unter Vorbehalt mit, obgleich sie wie erwähnt auf mehrjährigen Studien über die Konstanz der Pilze in Reinkultur aufgebaut ist.

Die Hauptaufgabe dieser Arbeit war nachzuweisen, dass die Abgrenzung von Ramularien, Mycosphaerellen und Nectrien unabhängig von Herkunft und Pathologie der Pilze rein morphologisch möglich ist, selbst wenn man allein auf Merkmale der Konidiengeneration angewiesen ist. Ebenso die Abgrenzung dieser Gattungen gegen *Fusarium* und Ascomyceten mit *Fusarium* ähnlichen Konidienformen, zu denen *Gibberella* und *Calonectria* gehören.

Ein von mir auch in Amerika entdeckter Schädling des Getreides ist der Erreger des sogenannten Schneeschimmels, (Tafel XXII, Fig. 29 bis 36) dessen Konidienstadium als *Fusarium nivale* seit langem bekannt ist, zu dem Ihssen (1910) die Schlauchform auffand, die er als *Nectria graminicola* Berkeley et Broome richtig bestimmte. Der Pilz hat oft 1-3-septierte Ascosporen, weshalb ich ihn *Calonectria graminicola* (Berk. & Brm) Wr. genannt habe (Phytopathology 1:34. 1913). Zu einem anderen Ergebnisse kommt in einer seiner gründlichen Arbeiten über Schneeschimmel (1911; 1912; 1913), Schaffnit (1913), indem er sich auf die Studien Weese's (1911) an dem Berkeley und Broome'schen Originallexsiccate der *Nectria graminicola* stützt. Weese fand dickschaligere Perithezien und etwas grössere Ascosporen vor. Wie gering aber die Dickschaligkeit dieser Originalperithezien gegenüber dünnchaligen Exemplaren einzuschätzen ist, sehen wir aus den Befunden mit Reinkulturen. Damit fällt aber das einzige wichtigere Argument, was gegen Ihssen's Bestimmung sprechen konnte. Die Tatsache, dass Berkeley und Broome bereits die Möglichkeit der höheren Septierung der Ascosporen erwähnen, spricht ebenfalls für die Identität auch dann, wenn Perithezien mit solchen von dem Originallexsiccate heute nicht mehr abgeerntet werden können. Die Notwendigkeit einer Neubenennung des Pilzes als *Calonectria nivalis* Schaffnit ist daher noch nicht einzusehen. Aus derartigen Strittigkeiten ersieht man aber immer wieder, was auch Weese besonders hervorhebt, die Notwendigkeit des Studiums der Pilze nach dem Leben. Bei der Nachbestimmung kann man selbstverständlich auf Exsiccate nicht immer verzichten. Soviel geschmährt sie auch sind, so gewähren sie doch in Verbindung mit Reinkulturen gute Einblicke, nichts so oft Entscheidung in schwierigen Fragen.

C. SYSTEMATISCHER TEIL

Zur Übersicht sei ein Schlüssel der besprochenen Gattungen vorausgeschickt. In diesem ist der Gegensatz, der aus dem Vorhandensein der Chlamydospore und aus der Gestalt der Konidie sich ergibt, besonders betont worden. Zur einem umfassenderen Gesamtbilde bedarf es einer

grösseren Anzahl von Beispielen. Die Züchtungen sind aber für viele nicht aufgenannte Pilze noch nicht abgeschlossen. Doch glaubte ich es nicht unterlassen zu sollen, schon jetzt Vorschläge einer Neugruppierung zu bringen, um eine Discussion über sie zu ermöglichen.

Bestimmungsschlüssel der Sectionen und Gattungen der Pilze dieser Arbeit

	SECTIO	GENUS
Chlamydosporen vorhanden		
Peritheccien unbekannt		
Konidien subcylindrisch, Basis apedicellat.....		Ramularia
Konidien spindelig sichelförmig		
Terminalchlamydosporen fehlen, Konidien pedicellat.....	Discolor	Fusarium
Terminalchlamydosporen vorhanden, Konidienbasis ellipsoidisch, kegelig oder subpedicellat		
Konidienbasis plump.....	Ventricosum	Fusarium
Konidienbasis kegelig oder ellipsoidisch	Eupionnotes	Fusarium
Konidienbasis subpedicellat.....	Martiella	Fusarium
Peritheccien bekannt		
Konidien subcylindrisch, Basis apedicellat.....	Ramulariella	Hypomyces
Konidien spindelig sichelförmig.....	Pseudomartiella	Hypomyces
Chlamydosporen fehlen		
Peritheccien unbekannt		
Konidien subcylindrisch, Basis apedicellat.....		Cylindrocarpon
Peritheccien bekannt		
Konidien eiförmig oder ellipsoidisch, Tubercularia Tode entsprechend	Tuberculariastrum	Nectria
Konidien subcylindrisch, Basis apedicellat, Cylindrocarpon entsprechend.....	Willkommmites	Nectria
Konidien Ramularia (Unger) Fr. entsprechend.....		Mycosphaerella
Konidien spindelig sichelförmig, Fusarium entsprechend.....		
Konidienbasis ellipsoidisch bis subpedicellat.....		Calonectria
Konidienbasis pedicellat, Discolor entsprechend, Peritheccien indigoblau.....		Gibberella

I. RAMULARIA (UNGER) FRIES.

Unger, Eryantheme p. 169. 1833; Fries, Summa veget. p. 493. 1849.
Fresenius Beiträge p. 88-90. 1863.

Konidien mehr oder weniger polar, oft dorsiventral am Scheitel, sonst radiär, cylindrisch oder schwach keulig, gerade oder kaum gekrümmt, mit ellipsoidischem Abschluss. Basis nie fussartig, dagegen oft papillenartig vortretend; Konidien gewöhnlich septiert, mehrere nacheinander erzeugt (gelegentlich zu wenigen kettenartig verklebt) am Ende einfacher oder verzweigter septierter Konidienträger. Konidien zerstreut, in falschen Köpfchen, in Sporodochien, oft säulenartig vorquellend; ferner gelegentlich als Pionnotes auftretend; in Massen hell (weiss, bräunlichweiss, buttergelb, elfenbeinfarben); Chlamydo-sporen einzeln oder gesellig, in Ketten oder Knäueln, terminal oder intercalar, nicht an besonderen Trägern; in Massen braun; Hyphen septiert, verzweigt, isoliert oder als Mycel in lockeren bis plectenchymatischen (besonders als Stroma) dunkel oder gelegentlich lebhaft gefärbten Verbänden; Schlauchformen unbekannt.

1. *Ramularia candida* (Ehr.) n.n. (Tafel XX, Fig. C-E und XXI, Fig. B)

Syn.: *Fusarium candidum* Ehrenberg, 1818. Sylv. myc. Berol., p. 24.
Exs. auth. Museum bot. Berol. Dahlem-Berlin. Schlechtendahl. Flora Berol.* 2: 24. 1824. ? *Ramularia saprophytica* Bubák. Ann. mycol. 4: 121. 1906. ? *Ramularia arvensis* Sacc. 1881 ? *R. calcea* (Desm.) Ces. 1881. ? *R. vincae* Sacc. 1881. ? *R. pratensis* Sacc. 1881. ? *R. sagittariae* Bres. 1896. ? *R. rumicis scutati* Allesch. (Litt. Cf. Lindau in Rab. Krypt. Fl. 8: 460, 489, 485, 441, 434, 442). *R. rumicis* Sacc. Fungi ital. no. 998. 1881.

Exs.: Ehrenb. Exs. reliquia aut. in Museo bot. Berol. Dahlem; Ellis et Everh. North Amer. Fungi 3082 (sub *Septocylindrium Magnusianum* Sacc.)

Die Konidien können zerstreut, in Sporodochien und als Pionnotes auftreten und dementsprechend ein fädiges, sklerotial oder thallös plectenchymatisches Stroma haben. Die kettenartig entstehenden Konidien verkleben oft zu säulenförmig vorragenden, buttergelben bis weissen Schleimen, die im Wasser leicht wieder zerfallen. Konidien schmalcylindrisch an den Enden ellipsoidisch bis subkonisch. Basis nicht papillenartig vortretend, Scheitelnarbe fehlend. 1 Scheidewand, durchschnittlich $20-29 \times 3-3.75 \mu$, seltener einzellig, $12-20 \times 2.25-3.5 \mu$; bis zu 9 per cent aller Konidien können 2-3 Scheidewände entwickeln; obere Grenze der Durchschnittstriseptate ist $40 \times 3.75 \mu$. Konidienträger der Sporodochien wiederholt wirtelig verzweigt, mehrere Wirtel oft so dicht übereinander, dass sie fast zusammenfallen, so dass falsche Wirtel mit doppelter Gliederzahl entstehen. Die Sterigmen

gesellig, in Büscheln bis zu 5 beobachtet. Plectenchyme oliv- bis kaffeebraun, auch zimmtbraun, gelegentlich olivgrün gesprenkelt, Luftmycel heller. Chlamydosporen selten, einzeln oder zu wenigen kettig verbunden, kugelig bis eiförmig, 5-8 μ dick. An Baumwurzeln, Berlin (Ehrenberg) im Humus und an teilweise abgestorbenen Wurzeln von *Daucus carota*, April 1910, Dahlem. An *Heracleum*-Stengeln, Böhmen (Budák). Der Humus- und *Daucus*-Pilz sind sehr schwache Wundparasiten an reifen Äpfeln (Clara Hasse, April, 1913). Vielleicht an Kräutern weit verbreitet in Europa. Auf Blättern von *Trientalis* in Michigan, Vereinigte Staaten (G. H. Hicks) (sub *Septocylindrium Magnusianum*).

2. *Ramularia Magnusiana* (Sacc.) Lindau (Tafel XX, Fig. F-H und XXI, Fig. A).

Cf. Lindau, Rab. Krypt. Fl. 8: 493-1906.

Syn. *Septocylindrium Magnusianum* Sacc. *Michelia* 1: 130. 1878. Exs. Otto Jaap, selecti exs. 444. Krieger, fungi saxon. 1184 (sub *Septocylindrium Magnusianum* Sacc. Kab. et Bubák, fungi imp. exs. 339). Konidien 1-septiert durchschnittlich 18-27 x 3.5-5 μ , selten einzellig, 10-20 x 3.5-4.5 μ . Höchste Septenzahl 3, wobei die Durchschnittsgrösse 30 x 5 μ beträgt. Kettig verklebte Konidienpaare auch unter Wasser beobachtet. Der Pilz färbt Reis im Alter rosa (La France) im Gegensatz zu *R. candida* (Ehr.). Im übrigen gleicht er letzterer Art in Farbenbild, Stroma, Bau der Sporodochien und Konidienverlagerung.

In Deutschland im Humus, Dahlem, März 1911; in Parenchymflecken der Knollen von *Solanum tuberosum* "Sorte Wohltmann" Warkotsch, Schlesien, März, 1911, assoziiert mit *Fusarium udum* (Berk.), *F. subulatum* App. et Wr. und *Tylenchus dipsaci*. Auf Kartoffel-Knollen aus Idaho, gezüchtet aus Saatgut von Maine, Nordamerika. Auf *Trientalis*-Blättern, Sachsen (Krieger), Schleswig Holstein (Jaap.), Jütland. Dänemark (Jens. Lind.) ? Am Wurzelhalse eines jungen Acer, Meetzen bei Holdorf, Oldenburg, April, 1911 (leg. Förster Grosskopf) (das verfärbte Gefässsystem des Wurzelhalses enthielt indes Mycel von *Verticillium albo-atrum* Reink. & Berth.).

3. *Ramularia eudidyma* n. sp. (Tafel XXI, Fig. C)

Syn. *Fusisporium didymum* Harting, Nieuwe Verh. erste Kl. Kon. Nederl. Inst. Amsterdam 12: 228. 1846. Tab. II., Fig. 2-4. *Fusarium didymum* (Hart.) Lindau, Rab. Krypt. Fl. 9: 574. 1909. Appel & Wollenweber; Grundlagen (1910), S. 38, Textabb. 2L; Kultur als Grundlage—Ber. Deutsch. Bot. Ges. 28: 437, Abb. 1E. *Ramularia didyma* (Hart.) Wollenweber, *Phytopathology* 3: 33. 1913. Fig. 1R.

Konidien zerstreut, in Sporodochien oder als Pionnotes. Kettenartige

Verklebung zu Säulen wie bei *Ramularia candida* (Ehr.). Konidienform cylindrisch bis keulenförmig, im Basaldrittel oft etwas dünner. Scheitel im Längsschnitt schief-spitzbogig; Basis papillenartig vortretend. 1 Scheidewand: durchschnittlich $20-30 \times 4.5-5.5 \mu$, selten einzellig, $7-12 \times 3-5.25 \mu$; bis 38 per cent aller Konidien können auch 2 bis 3 Scheidewände haben; die Durchschnittsausmasse steigen dann auf 43μ Länge, 6.25μ Breite. Farbe der Konidienmassen buttermilchgelb bis weiss, Konidienträger spärlich wirtelig verzweigt. Plectenchyme tief braun. Braune Chlamydosporen seltener terminal als intercalar, oft warzig, 1 bis mehrzellig, $8-11 \mu$ Durchmesser. Auf einer teilweise abgestorbenen Kartoffelknolle, Marienfelde bei Berlin, December, 1909. Auf der Erde eines Rosentopfes mit anderen Fusarien zusammen, April, 1911, Berlin. (leg. P. Magnus, col. et det. Wr.). Auf kranken *Rubus idaeus*—Wurzeln, vergesellschaftet mit *Nectria rubi* Osterw. Schweiz. (leg. Osterw. [sub *Fusarium* von *N. rubi*], det. Wr.).

4. *Ramularia anchusae* Massalongo (Tafel XXI, Fig. D)

Cf. Massalongo, Malpighia 8: 213, 1894. Lindau, Rab. Krypt. Fl. 8: 487, 1906. c. ic.

Exs. Migula, Krypt. Germ. Austr. Helv. fasc. 13 et 14, no. 86. Zahlbruckner, Herb. Musei Palat. Vindob. 1904. Allesch. et Schnabl, Fungi bav. 693.

Syn. ? *Ramularia saniculae* Linhart. Exs. fungi hung. 194, c. ic. 1883. Lindau, Rab. Krypt. Fl. 8: 481. 1906. ? *R. Kriegeriana* Bres. Hedwigia, S. 328, 1900.

Konidien zerstreut, in Sporodochien oder als Pionnotes, oft kettenartig verklebend, aber in Wasser leicht wieder zerfallend. In Farbenbild, Stroma und Bau der Sporodochien gleicht die Art *Ramularia eulidyma* (Wr.), die Konidien sind aber höher septiert, ihre Basis tritt nicht papillenartig vor, der Scheitel ist mehr rund- als spitzbogig. 1-3-meist 2 Scheidewände, durchschnittlich $24-42 \times 4, 5-6, 25 \mu$. Längste Konidio 50μ lang. Diagnose nach Kulturen des von nicht keimfähigen Körnern "braunkörnigen" Weizens (*Triticum vulgare*), Anhalt, Deutschland, isolierten Pilzes. Auf Anchusa-Blättern in Europa (Massal., Cavara, Jaap, Diedicke, Vill, v. Höhnelt, Stolz, Voss, Magnus).

5. *Ramularia macrospora* Fres. (Tafel XX, Fig., A, B, Tafel XXI, Fig. E)

Cf. Fresenius, G. Beitr. z. Mykol. Frankfurt a.M., 1863, S. 88. Taf. 11, Fig. 29-32.

Syn. *Fusarium polymorphum* Marchal (non Matruchot). Bull. Soc. Roy. Bot. Belg. 34: 145-148. 1895 pl. I fig. 1. *Septocylindrium radiculolum* McAlpine, Fungus Diseases of Citrus Trees in Australia and their Treatment. Dept. of Agric. Victoria S. 112. 1899 Figs. 173-175. *Fusarium rhi-*

zogenum Aderhold (non Pound et Clem.). Centralbl. Bakt. Par
 2. Abt. 6: 623. 1900 Fig. 1-3. ? *Ramularia equiseti* Massal. Atti Bot.
 Belg. 34: 145. 1895 Tab. I, fig. 1. ? *Fusarium lichenicola* Massal. Ann.
 Mycol. 1: 223. 1903. Sacc. Syll. 8: 675.

Exs. Krieger, Schädliche Pilze 191; Fungi sax. 638, 1540.

Konidien zerstreut, in Sporodochien oder als Pionnotes, in Massen buttergelb bis weiss. Zerstreute Konidien ellipsoidisch, einzellig oder septiert. Sporodochien- oder Pionnotes-Konidien cylindrisch, 1-3-septiert. Durchschnittsgrössen: einzellig $7-20 \times 3-5 \mu$; 1-septiert $15-30 \times 3,5-6,5 \mu$; 2- und 3-septiert $25-40 \times 4-7,5 \mu$ (Grenzen bis 50μ Länge und 9μ Breite). Konidienträger seltener mit in 2- bis 3-gliedrigen Wirteln angeordneten Seitenästen in Sporodochien, meist einfacher oder nicht verzweigt. Plectenchym und Chlamydosporen kastanienbraun besonders auf stärkereichen Substraten. Braune rundliche dickwandige Chlamydosporen in Ketten und Knäueln häufiger als einzeln; terminal und interkalar, $10-16 \mu$ breit. Weit verbreiteter Ubiquist der gemässigten Zone Europas und Nordamerikas. In kranken Kartoffelknollen: im Gefässsystem des Nabelendes, Frühjahr 1911, Dahlem, (Wr.); in braunen Parenchymflecken, erzeugt durch *Phytophthora*, Februar, 1911, Dublin, Irland, (leg. G. H. Pethybridge; col. et det. Wr.); im kranken Gewebe mit *F. subulatum* vergesellschaftet, Februar, 1912, Corvallis, Oregon, Vereinigte Staaten von Amerika, (leg. et col. F. D. Bailey, det. Wr.). In Apfelfrüchten, Oct. 1912, Washington, D.C. (leg. et det. Wr., coluit Clara Hasse); Dez. 1912, Boston, Massachusetts (leg. et col. Charles Brooks und Fischer, det. Wr.). Im Boden und an ober- und unterirdischen faulenden Pflanzenteilen (Blättern, Stengeln, Früchten, Knollen, Wurzeln) besonders der Dikotyledonen, aber auch an Monokotyledonen. Unter besonderen Umständen Wundparasit, beispielsweise an Kartoffeln (Wr.), Äpfeln (Clara Hasse, Charles Brooks et Fischer), und an Wurzeln des Apfelbaumes (?) (Aderhold).

6. *Ramularia olida* n. sp. (Tafel XX, Fig J-N und XXI, Fig. J)

Konidien zerstreut, in Sporodochien oder als Pionnotes, formverwandt mit der Konidienform von *Hypomyces rubi* (Osterw.), Wr. aber im ganzen schlanker und gerader. 3-5 Scheidwände: durchschnittlich $45-89 \times 6,25-8,5 \mu$.

Farbe der Konidien- und Mycelmassen buttergelb, wenn trocken weisslich. Kontrastfarben fehlen. Konidienträger wiederholt hoch wirtelig verzweigt. Chlamydosporen ein- bis zweizellig, selten dreizellig, dagegen häufiger in Knäueln; Durchschnittsgrösse: einzellig $7-12$ (Grenzen $6-17$) μ . Die Art ist durch einen äusserst starken, widrigen Erdgeruch ausgezeichnet.

Schwacher Wundparasit an Kartoffelknollen. Fundort: Selchow bei Berlin, 1910.

II. HYPOMYCES (FRIES) TUL.

(Cf. Tulasne, Ann. Sciences Nat. 4. 13:11. 1860.

Syn. *Hypocrea*, subg. *Hypomyces* Fries. Summa veget: 333, 1849. Entspricht *Nectria*, doch sind echte terminale Chlamydosporen vorhanden. Die Gattung zerfällt in drei Sectionen: *Euphypomyces*, *Ramulariella* und *Pseudomartiella*.

a. SECTIO *Euphypomyces* n. sect.

Ascosporen in der Reife mit stachelartig zugespitzten Enden.

Der Nachweis der für die meisten Arten dieser Gruppe angegebenen Chlamydosporen bedarf einer Bekräftigung durch die Reinzüchtung dieser Pilze, von der Aufstellung der Artenreihe ist daher noch abgesehen.

b. SECTIO *Pseudomartiella* n. sect.

Die Konidien stehen der Section *Martiella* des Genus *Fusarium* nahe. Ascosporen ohne stachelartig zugespitzte Enden. Vielleicht *Nectriopsis* Maire entsprechend.

Hypomyces ipomoeae (Hals.) Wr. (1913). Tafel XXII, Fig., 22-28. *Hypomyces solani* Reink. et Berth. (1879).

c. SECTIO *Ramulariella* n. sect.

Konidien *Ramularia* entsprechend.

Ascosporen ohne stachelartig zugespitzte Enden.

Hypomyces rubi (Osterw.) n.n.

Hypomyces rubi (Osterw.) n.n. (Tafel XXII, Fig. 14-16)

Syn. *Nectria rubi* Osterwalder, A. Über eine neue auf kranken Himbeerwurzeln vorkommende *Nectria* und die dazugehörige *Fusarium* generation. Ber. d. Deutsch. Bot. Gesellsch. 29: 611-622. 1911. Fig. Weese; Studien über Nectriaceen. Zeitschr. f. Gärungsphys. 1: 126. 1912. ? *Fusarium album* Sacc. Fungi italici Tab. 42. 1877 (auf *Ulmus campestris*).

Rubinrote Perithezien zitronenförmig mit papillenartigem Ostium. Durchschnittsgrösse 500 x 430-460 μ . Ascosporen zweizellig 16-19 x 4.5-5.25 μ . Konidien in Menge buttergelb von der Form der *Ramularia olida* Wr., aber mit stärker gekrümmter Längsaxe; meist 3-4-septiert, seltener bis 12 per cent aller 5-septiert. Durchschnittsgrösse: 3-5-septiert 47-60 x 5.25-8.5 μ . Terminale Chlamydosporen einzellig 7-10 μ . Ein rot-

violetter Mycelfarbstoff entwickelt sich besonders auf stärkereichem Substrate.²

Auf kranken Wurzeln von *Rubus idaeus* ("Baumforths Sämling") vergesellschaftet mit *Ramularia didyma* (Hart.) Wr. Wädensvil, Schweiz, Schweizerische Versuchsanstalt für Obst-, Wein und Gartenbau (leg. Osterwalder.)

III. *Cylindrocarpon* n. gen.

Die Konidienform entspricht der der Section Willkommiiotes des Genus *Nectria*. Schlauchform nicht nachgewiesen. Da die Schlauchform aber wahrscheinlich vorhanden ist und in der Kultur später auch auftreten könnte, so ist diese Gattung möglicherweise nur eine imaginäre, eine Formgattung, die verschwinden kann, sobald alle Schwierigkeiten überwunden und Verwechslungen und Widersprüche ausgeschlossen sind.

1. *Cylindrocarpon cylindroides* n. sp. (Tafel XXI, Fig. F)

Konidien subcylindrisch, mit geringer aber wahrnehmbarer Querschnittsabnahme von der Mitte nach den Enden zu. Scheitel und Basalzelle spitzellipsoidisch, nie halbkugelig oder abgeflacht im Gegensatz zu *C. mali*. Konidien zerstreut, in Sporodochien und als Pionnotes, buttergelb bis weiss, im Blütestadium mit 3-5 Scheidewänden, durchschnittlich $35-70 \times 4.5-6 \mu$ in Jugend-, Alters- oder Hungerstadien weniger septiert bis einzellig. Pleotenchym reduziert und im Gegensatz zu *C. mali* nie lebhaft rotbraun. Chlamydosporen fehlen. Auf teilweise abgestorbenen Zweigen von *Abies concolor* aus einer Baumschule des Kreises Pinneberg in Schleswig-Holstein, wo der Pilz seit mehreren Jahren die 2-3 Meter hohen gepropften *Abies* beständeweise vernichtete, während die aus Samen gezogenen Pflanzen gesund blieben. (vgl. Laubert's Auskunftserteilung im 6. Jahresb. Tätigkeit d. Kais. Biol. Anst. f. Land- u. Forstw. 1910, Berlin, 1911 p. 56 (sub *Nectria cucurbitula*). Danach scheint dieser Pilz identisch mit *Nectria cucurbitula* (Tode) Fries, obgleich Perithecien weder am Fundort noch in künstlichen Kulturen des Pilzes beobachtet worden sind.

2. *Cylindrocarpon mali* (Allesch.) n.n. (Tafel XXI, Fig. G).

Cf. Appel & Wollenweber, Grundlagen, 1910, p. 174, Tafel 2, 88-90 und 92 (sub *Fusarium Willkommii* Lind.) Kultur als Grundlage . . . Ber. Deutsch. Bot. Ges. 28:437, 1910. Fig. 1A und Taf. 13, Fig. 4 (sub *Fusarium Willkommii* Lind.).

² Diagnose der Schlauchform aufgestellt nach Osterwalder, die der Konidienform nach eigenen Folgekulturen des als von Ascosporen hergeleitet aus dem Phytopath. Lab, Willie Commelin Scholten, Amsterdam, bezogenen Osterwalderschen Originalstammes.

Syn. *Fusarium mali* Allescher. Ber. Bot. Ver. Landshut 12:137, 1892.

(Zylindrisch-keulige Konidien im Blutestadium 5-septiert, durchschnittlich $54-62 \times 5-6 \mu$, vereinzelt 6-, 7-septiert, subnormal einzellig oder 1-4-septiert. Durchschnittsgrossen: einzellig $11-12 \times 3-3.25 \mu$, 1-septiert $19-23 \times 3.5-4.25 \mu$, 2-septiert $30-42 \times 4.5-5.5 \mu$, 4-septiert $48-50 \times 4.75-5.75 \mu$, 6-7-septiert $68-6 \mu$. Farbe der Konidienmassen buttergelb bis weiss, der Plektenchyme rotbraun. Chlamydosporen fehlen.

Originalfundort: Innenwand des Endocarps eines Apfels, Berlin, 1908 (Wr).

Wundparasit, Erreger von Stammkrebs an Apfelhochstämmen "Gravensteiner und Engl. Wintergoldparmaine," erwiesen durch künstliche Impfungen von Konidien in Rindeneinschnitte (Wr. 1910-1911).

IV. NECTRIA FRIES

Cf. Fries, Summa Veg. Scand.: 387, 1849.

a. SECTIO *Willkommii* n. sect.

Konidien mit radiärer oder etwas schiefer breitellipsoidischer Scheitelzelle, nie mit eingeschnürter gestauchter noch lang herausgezogener Spitze. Basis kugelig bis ellipsoidisch abgerundet oder auch abgeplattet. 3-5 oder mehr Scheidewände; bei Herabzüchtung weniger septiert bis einzellig.

Beispiele. *Nectria galligena* Bres. (1901); *N. discophora* Mont. (1835); *N. coccinea* (Pers.) Fr. (1801, sub *Sphaeria*; syn. *N. ditissima* Tul.) *N. cucurbitula* (Tode) Fr.

1. *Nectria galligena* Bres. (Tafel XXI, Fig. H, Tafel XXII, Fig. 1-6)

Strasser, P. Pilzflora des Sonntagsberges (Niederösterreich) Verh. k. k. zool. bot. Ges. Wien 1901; S. 413. Weese, J. Zur Kenntn. d. Erregers d. Krebskr. an d. Obst- u. Laubholzbäumen. Zeitschr. f. d. landw. Versuchswesen in Österreich. 1911; S. 877-885. Taf. I. Zeitschr. f. Gärungsphysiologie 1: 132-137. 1912. Wollenweber, Phytopathology 3: 35. Fig. 1, o. 1913.

Syn. *Fusidium candidum* Willk. Die mikrosk. Feinde d. Waldes. 1866 S. 103. Tab. 5-7. *Fusarium candidum* Sacc. Syll. 18: 674. 1906. *Fusarium Willkommii* Lind., Rab. Krypt. Fl. 9: 551. 1909.

Exs. ref. cf. Weese (loc. cit., p. 13) 1911. Ferner Herb. Kais. Biol. Anst. Dahlem Apfelrindenkrebs "Sorte Kaiser Alexander" leg. Laubert, März 1908 (sub *Nectria ditissima* Tul.). Herb. Bureau of Plant Industry, Washington, D. C. Apfelrindenkrebs, leg. W. B. Taylor, Plymouth, Mass. Jan. 1903 (sub *Nectria mammoidea* Plowr.). Cavara. Fungi Longob. exsicc. 133. Acerrinde (leg. Cavara, in horto botanico ticinensi).

Perithezien einzeln oder gruppenweise meist auf einem deutlichen dem

Substrate ein- oder aufgewachsenen mit dem rotbraunen Konidienstroma identischen Stroma sitzend. Das Stroma kann klein sein, fehlt aber selten. Perithezien oval, mit nur schwacher, nie halsartiger Einschnürung unterhalb der Scheitelwölbung, die sich also nicht kopfartig heraushebt im Gegensatz zu *N. discophora* Mont. Die Scheitelwölbung des Peridiums setzt sich aus radial verlaufenden, nach aussen anschwellenden, oft konzentrisch um das Ostium angeordneten Schlauchfasern zusammen, sonst herrscht netzig schaumige Struktur des nach aussen warzig rauhen Peridiums vor. Ostium flach, nicht kraterartig vortretend. Mündungskanal von einem Periphysenmantel ausgekleidet, der aus dem Füllgewebe zwischen Peridium und Ascus hervorgeht. Perithezien durchschnittlich $400-450 \times 275-325 \mu$. Farbe rot bis rotbraun, trocken dunkler. Asci zahlreich, zwischen ihnen wenige mehrzellige weitlumige Paraphysen. Ascosporen zu 8, in der Mitte des sie enthaltenden Ascussackes oft 2-reihig, an den Enden zerstreut gelagert; ellipsoidisch bis oval, von glatter Oberfläche, 1 Scheidewand, durchschnittlich $14-16 \times 5-7.25 \mu$. Farbe der Ascosporen wie die der Konidien: buttergelb, wenn trocken weisslich. Konidienform (= *Fusarium Willkommii* Lindau): Cylindrisch keulige Konidien im Blütezustande 5-septiert, durchschnittlich $57-73 \times 4.75-6 \mu$, 6-septiert bis 82μ Durchschnittslänge. Sexseptaten können 30 per cent der Gesamtzahl ausmachen, während sie bei *Cylindrocarpon mali* fast stets fehlen. Chlamydosporen fehlen. Plectenchymatische Stromata rotbraun.

Verbreitung auf *Pirus malus* in Europa und Nordamerika; auf *Pirus communis*, *Prunus padus*, *Fagus*, *Fraxinus*, *Corylus*, *Acer* in Europa. Diagnose nach künstlichen Reinkulturen des von der Rinde von *Fagus silvatica* in Dahlem isolierten Pilzes.³

Wundparasit, Erreger von Stammkrebs an Apfelhochstämmen (Aderhold 1903); Nachweis für Bäume der Sorten "Gravensteiner und Engl. Winter-Goldparmaine" durch künstliche Impfungen von Konidien in Rindeneinschnitte (Wr. 1910-1911).

³ Die Diagnose Bresadola's gründet sich auf Naturmaterial von Holzkropfen von *Salix purpurea*; am Sonntagsberge, Nieder-Österreich (leg. P. Strasser). Weitere Fundorte (zusammengestellt von Weese): In den Donauauen von Schonbichl bei Tulln, Niederösterreich (leg. v. Hohnel); auf Weidenzweigrinde (ohne Gallbildung): Langschonbichl bei Tulln, Niederösterreich (leg. v. Hohnel); auf Rinde von *Salix caprea*; Czerneboh bei Rachlau in der sächsischen Lausitz (leg. Feurich); auf Faulbaumkrebs bei Triglitz in der Prignitz, Mark Brandenburg (leg. Otto Jaap); auf Apfelbaumkrebs in Saint Dié, Frankreich (leg. R. Ferry), Dahlem bei Berlin (leg. Aderhold); Dornberg bei Kronstein, Niederösterreich (leg. v. Hohnel) Triglitz in der Prignitz, Mark Brandenburg (leg. Otto Jaap); auf Birnbaumkrebs: Dahlem bei Berlin (leg. Aderhold); auf Eschenkrebs in Hamburg (leg. Otto Jaap) in den Thayaauen bei Lundenburg, Mahren (leg. Otto Bittmann); auf Eichenrinde: Småland, Schweden (leg. C. J. Johansson); auf *Populus nigra*; Doemitz, Mecklenburg (leg. Fiedler); auf Haselnusskrebs: Wien; auf unbestimmter Rinde: Falkenberg, Oberschlesien (leg. Plose); auf Ribes: Freudenthal, Oest.-Schlesien (leg. J. Weese).

Nectria discophora Mont. (Tafel XXI, Fig. O. Tafel XXII, Fig. 7–13)

Cf. Montagne, Prodomus Florae Fernandesianae. . . . 1835, No. 42. Syn.⁴ *Nectria Jungeri* P. Henn. Engler. Jahrb. 22: 75. 1895. v. Faber, Arb. a. d. Kais. Biol. Anst. Dahlem 6: 397. 1908. *N. capitata* Bresad. Hedwigia S. 299. 1896. *N. eustoma* Penz. et Sacc. Malpighia 11: 509. 1897. *N. cinnereo-papillata* P. Henn. Monsunia 1: 161. 1899. *N. striatospora* Zimmermann. Zentralbl. f. Bakt., Paras. . . . 7: 105. 1901. Fig. 6. Van Hall-de Jonge. Departm. van d. Landbouw Suriname. Bull. 20. 1909. c. ic. Petch, Cacao and Hevea Canker. Circ. und Agric. Journ. Roy. Bot. Gardens, Ceylon—Vol. 5, No. 13: 143–180. 1910. *N. Huberiana* P. Henn. Hedwigia 48: 104. 1908. *N. Anacardii* P. Henn. Annales Mycologici 6: 486. 1908. *N. theobromae* Massee. Kew Bull. 5: 218. 1908.

Perithezien einzeln oder gruppenweise, auf dem dem Substrate ein oder aufgewachsenen, oft mit Konidiensäulen gespickten Stroma sitzend; von gestreckt ovaler Form, ausgewachsen mit halsartiger Einschnürung, durch die das obere Drittel kopfartig hervortritt. Struktur der Perithezien wie bei *Nectria galligena* Bres. Ostiolum oft mit kraterartig vorspringender Wandung des Periphysen umkleideten Ausführungskanal der Ascosporen. Perithezien durchschnittlich 350–580 x 250–350 μ . Farbe rot bis rotbraun. Asci zahlreich, bis 100 in einem Perithecium, mit mehrzelligen weiltumigen Paraphysen. Ascosporen 8, in der Mitte des sie enthaltenden Ascussackes 2-reihig, sonst einreihig spiralig gelagert; seltener ellipsoidisch als schwach dorsiventral, oder von der Form eines Doppelkegels mit gemeinsamer Basis und in der Reife abgestumpften Spitzen. Exospor mit derbfasiger Netzstruktur, aussen runzelig oder mit anastomosierenden Riefen, die seltener meridian als spiralig gedreht verlaufen. Eine Scheidewand, durchschnittlich 25–32 x 7–12.75 μ (unreif oft nur 6 μ dick und beidendig spitzig); vereinzelt 3 Scheidewände, in welchem Falle die Dorsiventralität bis zu einer spindeligen Sichelform verstärkt werden kann. Farbe der Ascosporenmassen buttergelb, trocken weisslich. Konidien zerstreut oder in Sporodochien bzw. Pionnotes, oft säulenförmig hervorquellend, später mit Perithezien zwischen den Säulen oder kranzartig um sie herum. Konidienform wie bei *Nectria galligena*, häufig aber mehr gekrümmt und subdorsiventral, besonders die Scheitelzelle, die schiefellipsoidisch ist. Sieben Scheidewände, durchschnittlich 82–109 x 9–11.25 μ , seltener 8, ausnahmsweise mehr oder weniger Scheidewände. Farbe der Konidienmassen buttergelb; trocken weisslich. Konidienträger wirtelig verzweigt. Plectenchymatische Stromata rotbraun. Chlamydosporen fehlen.

Auf krebssiger Rinde und an Früchten im ganzen Anbaubetriebe von

⁴ Cf. v. Höhnelt und J. Weese. Zur Synonymie in der Gattung *Nectria*. Annales Mycologici 8: 464–468. 1910. Zur Synonymie der Nectriaceen. Annales Mycologici 9: 422–424. 1911.

Theobroma cacao, in Afrika, Asien und Amerika. Ferner auf *Albizzia*, *Anacardium*, *Derris*, *Thea*. Eine Schädigung durch den Pilz ist noch nicht nachgewiesen.

b. *SECTIO Tuberculariastrum* n. sect.

Nectrien mit einzelligen ellipsoidischen Konidienstadien vom Typus der *Tubercularia vulgaris* Tode. Chlamydosporen fehlen. Sclerotial plectenchymatische Stromata convex mit glatter, gelegentlich aber sphaerostilbeartig ausgebuchteter Oberfläche.

Nectria cinnabarina (Tode) Fr., *N. oropensoides* (Rehm) Bref., *N. peziza* Tode, *N. lichenicola* Ces.

V. *MYCOSPHAERELLA* JOHANSON

Cf. Johanson, Svampar fran Jsland, S. 163. 1884

Von einer Entscheidung über Einteilung und schärfere Umgrenzung dieser schwierigen Gattung der Sphaerellaceen muss abgesehen werden, bis Ergebnisse von einer grösseren Artenzahl vorliegen. Es ist aber vielleicht möglich die Arten mit *Ascochyta*stadium als *Pycnosphaerella*, die ohne *Ascochyta* als *Diplosphaerella* zu bezeichnen, wenn sie 16, als *Mycosphaerella*, wenn sie 8 Ascosporen im Ascus haben. Ob man ersterer Gruppe Gattungswert verleihen, die anderen als Sectionen einer einzigen Gattung auffassen muss, wird sich besser von einer monographischen Studie aus ergeben. Was meine eigenen Erfahrungen betrifft, so ist der Entwicklungsgang von *Mycosphaerella* sehr einfach. *Phoma* und *Phyllosticta*, *Septoria* und *Ascochyta* finde ich sehr häufig in Flecken mit dem Schlauchpilze vergesellschaftet, dagegen nicht in Reinkultur. Eine Polemik darüber, ob solche Formen und welche in den Entwicklungsgang von *Mycosphaerella* zu ziehen sind, wäre daher einstweilen verfrüht. Die Tatsache, dass etwa aus Ascosporen ein Mycel mit Konidien hervorgeht, die freien *Septoria*- oder *Ascochyta*-Konidien ähneln, beweist nur dann die Identität der fraglichen Gebilde, wenn umgekehrt aus der Pyknidenform die Perithezien einwandsfrei gezüchtet werden können. Solche Versuche sind aber selten durchgeführt worden.

1. *Mycosphaerella solani* (Ell. et Ev.) n.n. (Tafel XXI, Fig. N
Tafel XXII, Fig. 18, 21)

Syn. *Sphaerella Solani* Ellis et Everhart, Proceed. Acad. N. S. Philad. p. 134, 1893. Sacc. Syll. 11: 297. 1895. *Fusarium affine* Fautr. et Lamb., Espèces nouvelles de la Côte d'Or. Revue Mycol. France 18: 63. 1896.

Braune kugelige ovale oder subkonische Perithezien 90–150 μ dick, auf thallös oder sklerotial plectenchymatischem Stroma gesellig, seltener einzeln. Peridium rauh oder glatt, entweder dünn häutig, 5–12 μ dick, aus 1–2 Zelllagen bestehend oder einen aus mehreren (bis 5) Zelllagen zusam-

mengesetzten 25–35 μ dicken schaumig netzigen Mantel bildend. 1-septierte in der Reife etwas rauhe Ascosporen ellipsoidisch, durchschnittlich 9–14 x 2.50–3.75 μ . Konidien zerstreut, in Sporodochien oder als Poinnotes, in Masse bräunlichweiss, cylindrisch mit schiefspitzbogigem Scheitel und rundbogiger Basis ohne Ansatzpapille. 1-septiert, durchschnittlich 10–12 x 2.5–3.25 μ , seltener einzellig 3.5–9 x 1.75–2.50 μ . Chlamydosporen fehlen, sklerotial plectenchymatische Stromata vorhanden.

An *Solanum tuberosum*. An grünen Kartoffelstengeln schwarzbraune Streifen herverrufend. An teilweise abgestorbenen Kartoffelknollen häufig mit *Ramularia*, *Fusarium*, *Phoma* und *Sporotrichum* vergesellschaftet. In den nördlichen Vereinigten Staaten von Amerika.

Diagnose nach künstlichen Reinkulturen auf sterilisierten Stengeln verschiedener Pflanzen, auf denen sowohl von Konidien als von Ascosporen aus der ganze Entwicklungskreis erlangt wurde. In Impfversuchen an Knollen und Pflanzen der Kartoffel verschiedenen Alters war je nach Kulturbedingungen der Umfang der Schädigung so ungleichmässig, dass es weiterer Studien bedarf, um ein umfassendes Bild der Pathogenität dieses Pilzes gegenüber Kartoffel zu geben. Eine öfter mit ihm in der Natur vergesellschaftete *Phoma*, die auch Tomaten bewohnt, trat in Reinkultur der *Mycosphaerella*, wie zu erwarten war, nicht auf und verlangt besondere Beachtung.

2. *Mycosphaerella fragariae* (Tul.) Lind. (Tafel XXII, Fig. 17)

Cf. Lindau, Engler & Prantl, Natürl. Pflanzenfamilien 1, 1: 424. 1897. Scribner, Rep. of the Chief of the Sect. of Veg. Pathology, p. 334, 1887 (mit vollständiger Literatur). Dudley, on the Strawberry Leaf-blight. Cornell Univ. Agr. Exp. Sta. Bull. 14: 171. 1889. 9 figs.

Syn. *Stigmatea fragariae* Tulasne (excl. *Ascochyta Fragariae* Lasch), Selecta fung. Carpologia 2: 286. 1863 pl. 31. *Sphaerella fragariae* Saccardo, Michelia 1: 536. 1879. Syll. 1: 505. 1882. *Sphaeria fragariae* Fekl., Frank, Krankh. d. Pflanzen. 607. 1880. *Sphaeria fragariaecola* Wallroth, Flor. crypt. Germaniae 2: 767. *Ramularia fragariae* Peck, New York State Museum Nat. Hist. Rep. 34, 30, 31. 1881. Plate 3, figs. 12, 15. *Ramularia Tulasnei* Saccardo, Syll. 4: 203. 1886. Trelease, The spot disease of the strawberry leaves. Wisconsin Agr. Exp. Sta. Ann. Rep. 2: 47–58. 1885. 3 figs. ? *Sphaerella tussilaginis* Rehm. *Ramularia brunnea* Peck. Rep. N.Y. Sta. Mus. 30: 55. 1877.⁵

Perithecien und Ascosporen vgl. *Mycosphaerella solani* (Ell. & Ev.) Wr. Konidien cylindrisch, kettenförmig verklebt, 1–3-septiert 25–45 x

⁵ Die Morphologie von *Mycosphaerella tussilaginis* hat Wolf studiert (1912). Sie scheint völlig mit *M. fragariae* übereinstimmend. Da diese Pilze nicht so hoch adaptiert scheinen, wie man annahm, so wird die Synonymik dieses Pilzes noch weiter wachsen, falls man der Frage eingehender nachgeht.

3-3.5 μ , in Massen bräunlichweiss. Chlamydosporen fehlen. Sklerotial plectenchymatische braune Stromata vorhanden.

Fleckenbildender Parasit auf *Fragaria*-Blättern. Im ganzen Anbaubiet der Erdbeere, besonders in Europa und Amerika verbreitet.

VI. CALONECTRIA DE NOT

Calonectria graminicola (Berk. et Brm.) Wr. (Tafel XXII, Fig. 29-36)

Vgl. Wollenweber, H. W. *Phytopathology* 3:34. February, 1913.

Wichtigste Literatur: Unger, Sorauer, Ihssen, Hiltner, Mortensen und Schaffnit. Schaffnit's (1912 und 1913) Arbeiten enthalten die Gesamtliteratur des Pilzes.

Synonymik: ? *Nectria graminicola* Berkeley et Broome (Ann. Mag. Nat. Hist. 3 ser. 3: 376, 1859). ? *Calonectria nivalis* Schaffnit (Mycol. Centralbl. 2: 257. 1913). *Fusarium nivale* autorum pro parte. *Fusarium hibernans* Lindau (1909). *Fusarium minimum* Fuckel (1869). *Fusoma triseptatum* Sacc. Syll. 10: 566. 1892. *Fusoma biseptatum* Sacc. in Grevillea 21: 69. 1893. tab. 184, Fig. 15; Syll. 11: 607. 1895.

Braune, immers angelegte, später je nach Substrat hervorbrechende Perithezien durchschnittlich 125-200 μ (Grenzen 75-300 μ) dick. Spindelförmige, subdorsiventrals, fast gerade, ockerfarbige Ascosporen 1-3-septiert, 12-15 x 2.75-3.75 μ . Ocker-bis lachsfarbige Konidien 3-septiert, 23-26 x 3.25-4 μ (Grenzen 15-30 x 2.5-4.5 μ), kommaförmig mit spitzigem Scheitel und abgerundeter selten subpedicellater Basis. Chlamydosporen fehlen; plectenchymatische Stromata thallös oder sklerotial, ocker-bis lachsfarbig wie das Mycel. Erreger der Schneeschimmelkrankheit des Getreides in Europa und Nordamerika. An wilfwachsenden Gräsern häufig.

Diagnose nach dem von einem nicht keimfähigen Weizenkorne isolierten Stamme, Dahlem-Berlin (leg. Wollenweber 1911).

Der Pilz ist mit amerikanischen von Schneschimmel-Getreide isolierten Stämmen identisch und bildet stets unter gleichen Kulturbedingungen die gleichen Perithezien und Konidien. Er ist vielleicht, wie ich nach einem Briefwechsel mit Herrn Dr. Schaffnit annehmen darf, auch mit dem von diesem studierten Stamme identisch. Dr. Schaffnit überliess mir kürzlich eine Folgekultur seines Originalpilzes *Fusarium nivale*, aus der ich Konidien züchtete, die denen meiner Stämme glichen. Perithezien entstanden bisher nicht, was aber an der schwierigen Züchtung dieser Fruchtform liegen mag. Da aber Schaffnit Chlamydosporen angibt und die von ihm gezüchteten Perithezien nicht immers angelegt sind und lachs bis ziegelrote, erst später braunrote Farbe haben, so bin ich von einer Identität unserer Stämme noch nicht ganz überzeugt und habe der etwas erweiterten Diagnose den von einem Weizenkorne isolierten Dahlemer Pilz zugrunde gelegt, der mit Sill, r-nitrat sterilisierte, in Reagenzgläsern in Nährlösung gezüchtete Getreidekörner nach ihrer Keimung angreifen kann.

MESSBELEGE ZU DEN REIN GEZÜCHTETEN PILZEN

Belege für einige Schlauchformen

PERITHECIEN, ERHALTEN IN FOEGEKULTUREN EINER REINKULTUR BEI AUSSAAT		ALTER DER KULTUR IN TAGEN		DURCHSCHNITT IN ALSMASSE (VON JE 10 STÜCK)	
einer	aufsteril			Perithezien Länge u. Breite	Ascioporen 1-septiert
				micron	micron
<i>Nectria disco- phora</i> Montagne	Nach Folgekulturen des	7-septierten			
	Synonym Nectria stria- tospora (Zimm.) de	Konidie	21	579 x 340	{ 31 x 6 (unreif) 29 x 9 (reif) 30 x 6 (reif) 29 x 10
	Jonge, bezogen April	Kartoffelstengel	300	546 x 343 (sehr trocken)	
	1910 aus dem Phyto- path. Lab. W. C. Schol- ten, Amsterdam.	Kartoffelknolle	130	350 x 250	{ 30 x 9 25 x 7 30 x 8 (1-sept.) 31 x 8 (3-sept.) ausnahms- weise 28 x 11
		Lupinusstengel	30	486 x 293	
		Lupinusstengel	21	480 x 299	
7-septierten Konidie	Apfeltriebe 2- jährig	30		Ausmasse liegen in normalen Schwankungs- gebiete.	31 x 12.5 (von Ascioporen- ballen vor dem Ostholium)
	Alnustriebe	30			
	4 cm. dicken Alnus-Ästen	42			31 x 12.75
Asciospore					
Gesamtschwankung absolut				300-700 x 200-400	20-40 x 5-14
				300-400 x 210-260	28-32 x 8-10
<i>N. striatospora</i> (Zimm.) de Jonge (Natur- material)	Messungen von Naturpei- thecien der Kakaorinde nach Frau van Hall de Jonge. Extrait du Recueil des Travaux botaniques Néerlandais. 6: 15. 1909				

<i>N. striatospora</i> (Zimm.) (Naturmaterial)	Zimmermann A., Über einige an Kulturpflanzen beobachtete Pilze I. Centr. f. Bakt. Paras. 2: 105. 1901			?	23 x 9
<i>N. galligena</i> Bres. (nach künstlichen Reinkulturen des Verf's)	Perithezien von Rotbuchenrinde (ohne Krebs) von Asco-sporen.	5-septierten Konidie einer Folgekultur von Asco-sporen.	Kartoffelstengel	180 452 x 315 393 x 286	16 x 7.25 (überreif, feucht) 16 x 6 (normal) 14 x 5.25 (notreif oder unreif)
		Gesamtschwankung absolut		200-600 x 200-400	10-20 x 4-8
<i>N. galligena</i> Bres.	Original-Diagnose Bresdola's erweitert durch Weese (1911) p. 877-878 auf Grund zahlreicher Vergleichsstudien an Exsiccaten und Naturmaterial.			(?) x 250-300 (200-300)	14-20 x 5-7.5 (18-20 x 7-8, Originalausmasse bei Bresadola)
<i>N. galligena</i> Bres. (Naturmaterial)	Naturperithezien von Krebsstellen eines Apfelbaumes, Sorte "Kaiser Alexander" (leg. Lambert 30. März 1908) Sammlung d. Kais. Biol. Anst. Dahlem.			438 x 355	16-20 x 6.5

AUSMASSE UND SEPTIERUNG DER KONIDIEN
Belege nach normalen Sporodochien oder Pionnotes aus künstlichen Reinkulturen auf Vegetabilien
 Durchschnittsausmasse von je 10 Konidien und Mengenverhältnisse der Septaten

NAME DES PILZES	NO. VON BELEG	KULTUR AUF STERIL.	0-SEPTIERUNG				1-SEPTIERUNG				2-SEPTIERUNG				3-SEPTIERUNG			
			micron		micron		micron		micron		micron		micron		micron		micron	
<i>Ramularia candida</i> (Ehr.) isoliert von faulenden Karottenwurzeln Dahlem-Berlin	30	Kartoffelstengel	16 x 2.5		27 x 3		100											
	21	Kartoffelstengel	17 x 3.75		20 x 3.75		84											
	21	Strohhalme			24 x 3.25		100											
	60	Lupinestengel	15 x 3.25		25 x 3.75		90											
		Baumwollstengel	20 x 3		29 x 3.5		91						5		40 x 3.75		4	
<i>R. Magnusiana</i> (Sacc.) Lind. isoliert von einer kranken Kartoffelknolle von der Domäne Plohe bei Warkotsch, Schlesen	24	Kartoffelstengel			27 x 4.5		100											
	24	Kartoffelstengel (trockener)	13 x 3.5		22 x 3.5		100											
	30	Kartoffelstengel			24 x 4.5		100											
	8	Kartoffelknolle	15 x 3.5		18 x 4		100											
	30	Kartoffelknolle			24 x 4		100											
	20	Baumwollstengel			24 x 5										30 x 5			
	46	Kartoffelstengel	15 x 4		26 x 4.5		100											
<i>R. eudidyma</i> n. sp. isoliert von einer teilweise abgestorbenen Kartoffelknolle, aus Marienfelde bei Berlin	14	Kartoffelstengel	12 x 5.25		1		25 x 5.25		98		36 x 5.75		1		35 x 5.75			
	20	Kartoffelstengel (trockene Sporodochien)			28 x 4.75						35 x 5.5							
	20	Baumwollstengel (sehr feucht)	11 x 5		11		27 x 5		80		39 x 5.5		2		43 x 5.5		7	
	50	Kartoffelstengel			28 x 5.5				89		35 x 6.25		10		36 x 6.25		1	
		Kartoffelstengel (Trocken-Pionnotes)			21 x 4.25				100									
	8	Vicia faba-Stengel			29 x 5													
	14	Vicia faba-Decoct	7 x 3.5		2		27 x 5		60		39 x 5.25		11		43 x 5.5		27	

auch warzige Chlamydosporen fanden sich im Kondenswasser später

<i>R. anchusae</i> Massalongo isoliert von einem nicht keimfähigen Korne "braunkörnigen" Weizens, Domäne Buhlendorf, Lindau, in Anhalt	20	Kartoffelstengel.....	1	37 x 5	53	39 x 5.25	45	1
	30	Kartoffelstengel.....	3	31 x 6	16	36 x 6	81	5
	33	Strohalm.....	17	35 x 5.75	21	39 x 6.25	57	40 x 6.25
	33	Strohalm (trocken).						42 x 5
	20	Fragaria blättern.....	7	16 x 3.25	81	29 x 3.75	6	32 x 4
	23	Baumwollstengel...			4	40 x 5.75	60	42 x 5.75
	33	Vicia faba-Stengel.....		33 x 4.5	55	37 x 5	45	
	33	Weizenkörner (Pionnotes)...		31 x 5.5	10	36 x 6	41	42 x 6.25
	33	Weizenkörner (sehr trocken).		24 x 4.5	99		1	49
	33	Reis (oberflächliches Konidienpulver).....		29 x 5	87	35 x 5.5	14	
<i>R. macrospora</i> Fresenius isoliert von braunen Parenchymflecken einer kranken Kartoffelknolle, Dublin, Ireland. (leg. Pethybridge)	21	Baumwollstengel.....						36 x 5.25
	13	Kartoffelstengel (sehr feucht)		25 x 6.5	11	30 x 6.5	25	38 x 7
	13	Kartoffelknolle.....		27 x 6.5	30	29 x 0.75	27	33 x 7
	13	Kartoffelknolle (trockene Konidien).....		26 x 5.5		30 x 5.75		33 x 6
	13	Vici faba-Stengel (sehr feucht).....		24 x 6.5	77		17	31 x 7
	11	Reis (feucht).....	3	29 x 5.5	2		25	38 x 6.5
	33	Reis (trocken).....		25 x 4.5	27	28 x 4.5	20	31 x 4.75
	33							53

AUSMASSE UND SEPTIERUNG DER KONIDIEN—Fortsetzung

NAME DES PILZES	KULTUR AGENT	3. SEPTIERUNG			% d. SEPTIERUNG		
		micron	micron	micron	micron	micron	micron
<i>Rhizoglyphus</i> sp. isoliert von einer kranken Kartoffelknolle vom Ruttergute Neuhaus, Salchow bei Berlin	21	59 x 7	12 77 x 8	49 74 x 8	39		
	30	45 x 6 25 94	5	25	29		
	60	62 x 8 25 37 68 x 8 25 54 69 x 8 25 9	26 72 x 7 75 24	5	44		
	30	53 x 7	50	22	22		
	30	62 x 8 5	9 66 x 8 5	59 70 x 5 5 32	25		
	60	19	26	55	55		
	14	66 x 8	23 70 x 8	53 73 x 8	24		
	21	Kondientyp		72 x 8 5			
		Maiskörner (feuchte Pionnotes) breitleicher Kondientyp		89 x 6 5			
<i>Hypomyces ruber</i> (Ostrya) n. n. isoliert von Rubus idaeus (leg. Osterwalder, Schweiz) Nach Folgekulturen der angeblich von Ascospora hergeleiteten Kondienform, bezogen Nov. 1912 aus dem Phytopath. Lab. Wilhelm Commelin Scholten, Amsterdam	21	48 x 6 75 100	0	0	0		
	21	57 x 8	80 60 x 8 5	20	12		
	21	47 x 5 25	55 x 5 5	59 x 5 75	0		
	30	48 x 5 75	56 x 5 75	59 x 6			
	10	53 x 8	50 56 x 8	42 56 x 8	8		
	60	52 x 7 5	55 55 x 8 25	41 58 x 8 5	4		
	60	55 x 8	34 53 x 8	62 56 x 8 25	4		
	60	54 x 5 25	56 x 5 25				
	60	50 x 8 75					

NAMEN DER PILZE	1. AUGUST	2. SEPTEMBER	3. SEPTEMBER	4. SEPTEMBER	5. SEPTEMBER	6. SEPTEMBER	7. SEPTEMBER	8. SEPTEMBER
9 Kartoffelstengel	11 x 3	25 x 4	39	2 51 x 5 75	15 51 x 5 75	6 65 x 6	35	
12 Kartoffelstengel			6		2	8	76	82 x 5 75
16 Kartoffelstengel			1		6	3	62	81 x 5 75
20 Kartoffelstengel			2			2	91	25 94 x 5 75
24 Kartoffelstengel			2			8	54	30
30 Apfelnäbe			14		4	9	58	80 x 6
30 Apfelnäbe (pul- venige Sporodo- chien)			36		23	24	69	x 4 75
90 Apfelnäbe (pul- venige Sporodo- chien)			10		6	12	63	x 5 5
30 Aesculusnäbe			12		9	15	62	x 5 75
30 Reis			7		13	44	57	x 6

NAMEN DER PILZE	1. SEPTEMBER	2. SEPTEMBER	3. SEPTEMBER	4. SEPTEMBER	5. SEPTEMBER	6. SEPTEMBER	7. SEPTEMBER	8. SEPTEMBER
14 Kartoffelstengel (feuchte Kondien- ballen)		1	2 53 x 5 25	80 61 x 5 5	12	65	x 5 5	5
14 Kartoffelstengel (Sporodochien)		3	1 51 x 5 5	62 65 x 5 75	28	70	x 5 75	6
24 Kartoffelnolle (Pionnotes)		1	15 35 x 5	28				
50 Apfelnäbe	9 x 4 5	1 22 x 5	4	27				
50 Apfelnäbe (normale Sporodochien)	9 x 3 5							
50 (Trockenstadium)								

Cylindrocarpum cylindroides
absterbender Zweige von
Bsp von Sporodochien
Abres Pinnel var. *violacea*
Kreuz Pinnel, Holstein,
Deutschland

AUSMASSE UND SEPTIERUNG DER KONIDIEN—Fortsetzung

NAMES DES FILICES	Page	KULTUR AUF STERIL.	3-SEPTEMBER	%	4-SEPTEMBER	%	5-SEPTEMBER	%	6-SEPTEMBER	%	7-SEPTEMBER	%	8-SEPTEMBER	%	9-SEPTEMBER	%	
30 Lupinestengel . . .											1	109 x 10.25	64	113 x 10.25	25	118 x 10.75	10
40 Lupinestengel (Konidiensaul- chen)																	
40 Lupinestengel (Honigartige Tropfen)											2	100 x 10.5	62	103 x 10.5	33		3
40 Lupinehülsen . . .											5	80 x 9.5 x 9	63		29		4
40 Buchentriebe. . .											24	94 x 11.25	66	x 9	2		1
40 Vicia faba-Stengel..											5	109 x 10.75	80	112 x 11	13		1
270 Vicia faba-Stengel (honigartige Tropfen)																	
50 Apfeltriebe. .											11	100 x 11.25	66		23		
30 Erletriebe . . .											15	91 x 11.5	74		8		
30 Weizenkörner (Pionnotes)			1		5		32		27		82 x 10	35					

ZUSAMMENFASSUNG DER RESULTATE

1. Ascomyceten mit septocylindrischen Konidien sind unter ausschliesslicher Benutzung künstlicher Reinkulturen morphologisch unterscheidbar und zerfallen in natürliche Gruppen, für deren Aufstellung die Konidiengeneration Leitmerkmale bietet.

2. Pilze mit septocylindrischen Konidien scheiden aus der Gattung *Fusarium* aus und gehören, soweit die Schlauchform nachgewiesen ist, zu *Nectria* (sectio *Willkommii*), *Hypomyces* (sectio *Ramulariella*) und *Mycosphaerella*; soweit die Schlauchform unbekannt ist, zu *Cylindrocarpon*, falls Chlamydosporen fehlen, zu *Ramularia*, falls Chlamydosporen vorhanden.

3. Die Gattung *Hypomyces* zerfällt in mehrere Sectionen z. B. *Euhypomyces*, *Ramulariella*, *Pseudomartiella*, welche das Vorkommen echter Chlamydosporen gemeinsam haben, aber durch Merkmale der Ascosporen und Konidien voneinander abweichen. Das Vorkommen bzw. der Standort ist vernachlässigt.

4. *Nectria galligena* Bres., der Erreger des europäischen Krebses der Obst- und Laubholzbäume und *Calonectria graminicola* Wr., der Erreger des Schneeschimmels an Getreide, existieren in den Vereinigten Staaten von Amerika.

5. Die Gattung *Ramularia* enthält eine Reihe ubiquistischer Wundparasiten. *Septocylindrium* ist von *Ramularia* nicht zu trennen und kann eingezogen werden.

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ERKLÄRUNG DER TAFELABBILDUNGEN

Allen Figuren liegen Reinkulturen auf sterilisierten Stengeln und Ästen von Pflanzen zugrunde.

Für die Reproduction war eine Revision der Originaltafeln nötig, die Herr Brewer in dankenswerter Weise übernommen hat. Bei diesem Verfahren ging die Schattierung der Originalzeichnungen teilweise verloren, sodass der plastische Effect derselben nicht überall zum Ausdruck kam.

TAFEL XX

FIG A-N *Ramularia*-Arten dargestellt nach Reinkulturen auf sterilisierten Stengeln und Ästen von Pflanzen. Vergrößerung $\times 400$, ausgenommen N $\times 800$.

A, B *Ramularia macrospora* Fries. A, Konidientrager mit normalen Konidien, B, Chlamydosporen. I u. 2 Konidiochlamydosporen.

C-E *Ramularia candida* (Ehrh.) N. N. C, D, Konidientrager aus einem Sporodochium, E, Chlamydosporen.

F-H *Ramularia Magnusiana* (Sacc.) Lind. F, 2 Mutterkonidien mit in Konidientrager umgewandelten Keimschläuchen, G, Konidientrager mit normalen Konidien, H, gequollene Konidien bei abnormer Keimung.

J-N *Ramularia olida* n. sp. J, Chlamydosporen, K, Konidien, L, Konidientrager aus einem Sporodochium, M, Junger Konidientrager, N, Normale Konidienform.

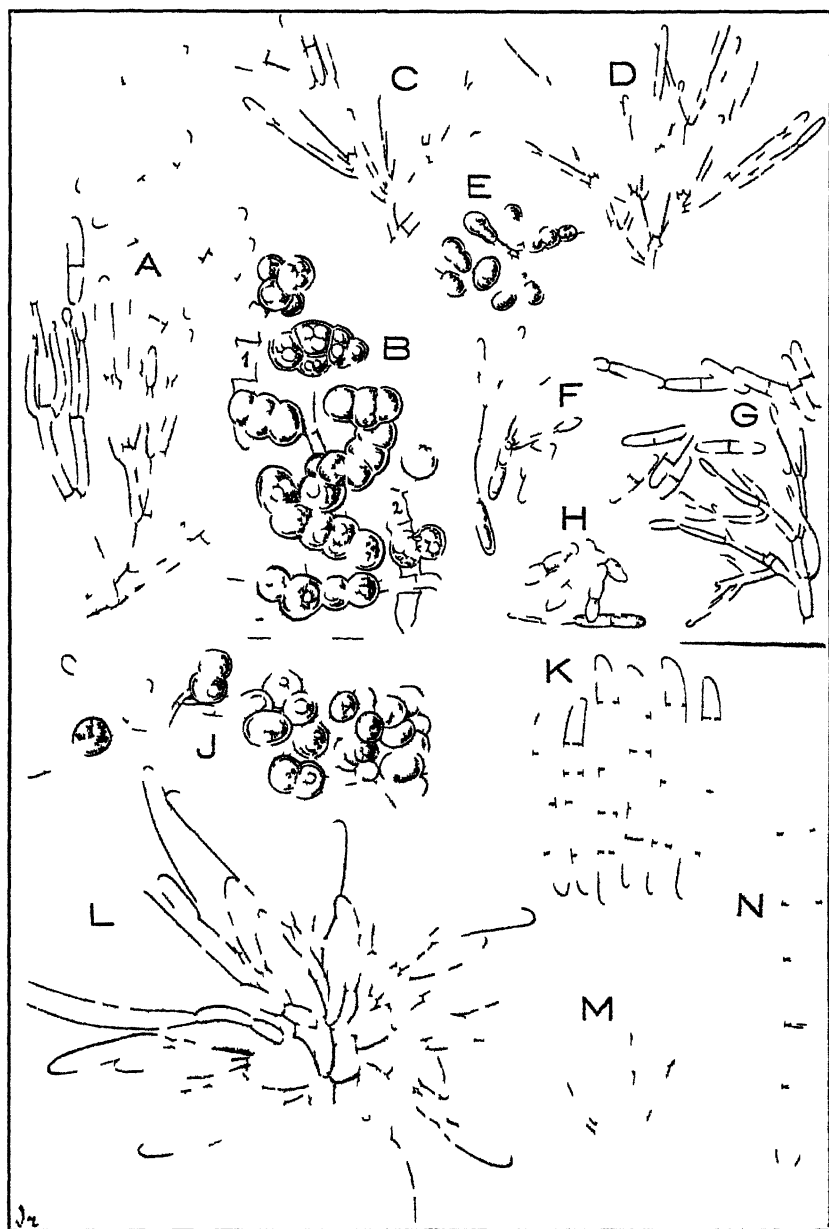
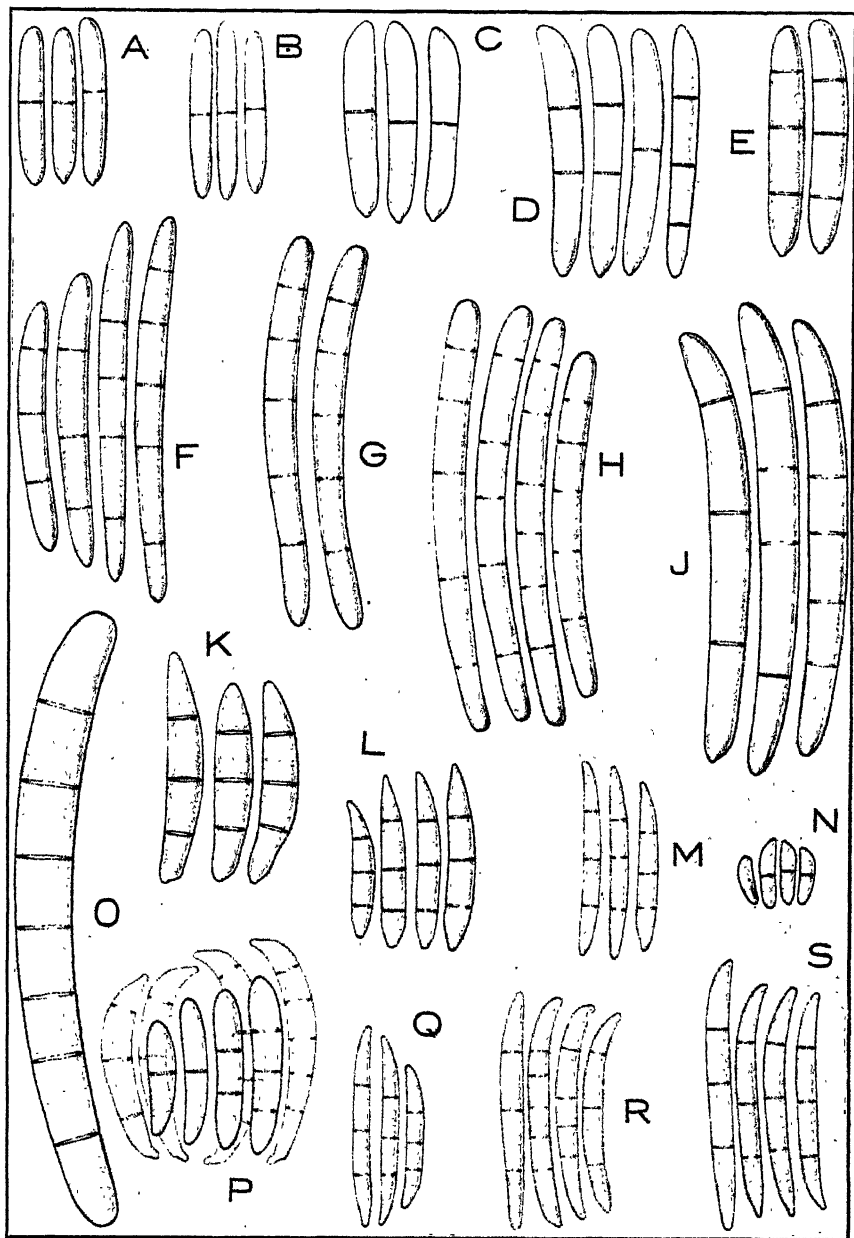


TABLE XX

TAFEL XXI

FIG. A-S. Normalkonidien einiger Pilze mit septocylindrischen und verwandten Konidienformen. Vergrößerung $\times 800$.

A, *Ramularia Magnusiana* (Sacc.) Lind. B, *R. candida* (Ehr.) n. n., C, *R. eudidyma* (Hart.) Wr.; D, *R. anchusae* Massal; E, *R. macrospora* Fres; F, *Cylindrocarpon cylindroides* n. sp. [?= *Nectria curcurbitula* (Tode) Fr.]; G, *C. mali* (Allesch.) n. n.; H, *Nectria galligena* Bres.; J, *Ramularia olida* n. sp.; K, *Fusarium ventricosum* App. et Wr., L, *F. semitectum* B. et. Rav; M, *F. orthoceras* App. et Wr.; N, *Mycosphaerella solani* Ell. et Ev.; O, *Nectria discophora* Mont.; P, *Fusarium trichothecioides* Wr. (oben subnormales, unten Sporodochienstadium); Q, *F. udum* var. *pusillum* n. v.; R, S, *F. udum* (Berk.).



TAFEL XXI

TAFEL XXII

Fig. 1-36 Verschiedene vom G. züchteten Ascomyceten

1-6 *Nectria gulligena* Bacc. 1 Konidienträger $\times 250$ 2 Konidien $\times 500$ 3 Asci mit Paraphysen $\times 250$ 4 Ascosporen $\times 500$ 5 Peritheciengruppe $\times 25$ 6 Reifes Perithecium im Längsschnitt $\times 100$

7-13 *Nectria discophora* Mont. 7 Konidienträger $\times 250$ 8 Konidien $\times 500$ 9 Junge Ascosporen (daunter eine seltene Triseptate) $\times 500$ 10 Reife Ascosporen, die erste im Längsschnitt die anderen von oben gesehen $\times 500$ 11 Gruppe junger Asci mit Paraphysen $\times 100$ 12 Reifes Perithecium teils von oben teils im Längsschnitt gesehen. Das Peridium ist teilweise abgehoben $\times 100$ 13 Ascus $\times 250$

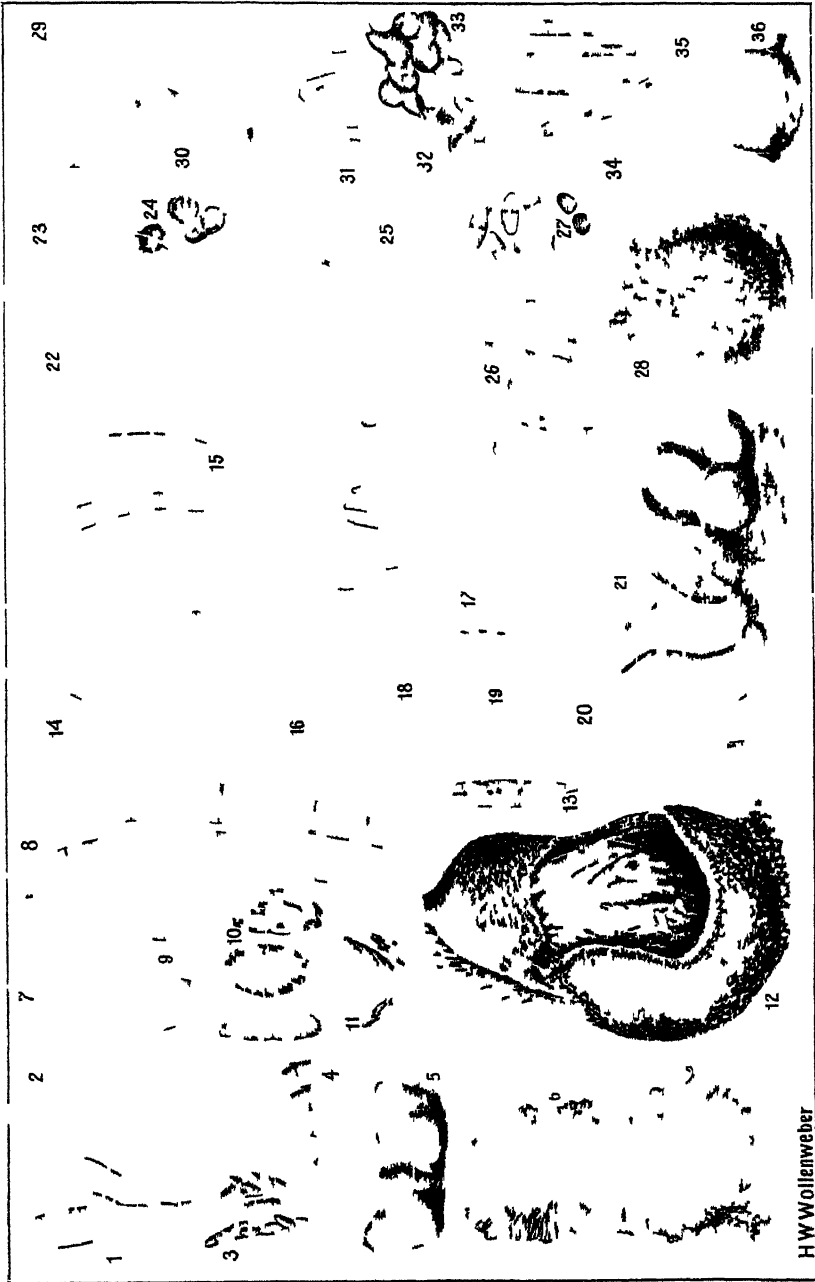
14-16 *Hypomyces rubi* (Osterw.) n. n. 14 Sporodochium $\times 250$ 15 Konidien $\times 500$ 16 Chlamydosporen in Keimschläuchen 8 Tage gewässerter Konidien $\times 100$

17 *Mycosphaerella fragariae* (Lul.) Lindau. In der Mitte ein Sporodochium mit normalen Konidien rechts und links je ein Konidienträger $\times 500$

18-21 *Mycosphaerella solani* (Ell. et Ev.) n. n. 18 Konidien $\times 500$ 19 Ascosporen $\times 500$ 20 Asci $\times 500$ 21 Peritheciengruppe $\times 100$

22-25 *Hypomyces ipomoeae* (Hulsted) W. 22 Konidien $\times 500$ 23 Falsches Konidienköpfchen aus Wasserkultur (Hungerkonidien) $\times 250$ 24 Chlamydosporen $\times 500$ 25 Konidienträger $\times 250$ 26 Asci mit sonst sehr seltenen Paraphysen $\times 250$ 27 Ascosporen unten eine in ihre Teilzellen zerfallende überreife $\times 500$ 28 Perithecium

29-36 *Clonectria graminicola* (Berk. et Bim.) W. 29 Konidien $\times 500$ 30 Konidienträger $\times 500$ 31 Endobiotisches Mycel im Begriff ein plectenchymatisches Stroma zu bilden $\times 500$ 32-33 Beispiele sklerotider Plectenchymgruppen die häufig als Basis der Fruchtkörper dienen $\times 500$ 34 Ascosporen $\times 500$ 35 Asci $\times 250$ 36 Perithecium $\times 100$



H.W. Wollenweber

PLATE XVII

FOOT ROT, A NEW DISEASE OF THE SWEET POTATO

L. L. HARTER

WITH TWO FIGURES IN THE TEXT

In August, 1912, specimens of diseased sweet potatoes (*Ipomoea batatas*) from the Dismal Swamp region of Virginia were sent to the writer for examination. A study of the material showed that the disease was caused by an organism hitherto unknown for the sweet potato. A visit to the region a little later proved that it was also a very serious trouble, as many as 95 per cent of the plants in some fields being diseased. The losses which can be directly charged to this disease have been so great the last few years that many of the farmers have threatened to give up growing the crop.

The organism causing the foot rot disease attacks the cortex of the stem, turning it black from a little below the soil line to 3 to 5 inches above it. Under greenhouse conditions, it requires about one month after infection to overcome the plant sufficiently to cause wilting. In the field, a rapidly growing plant will often survive longer. The first visible sign of the disease is a blackening of the lower part of the stem followed by a yellowing and dying of the lower leaves. After 3 or 4 inches of the stem have turned black, the plant wilts and gradually dies. Previous to this time, or before wilting occurs, pycnidia form on the blackened area and continue to increase in number, if sufficiently moist, for some time after the death of the plant.

Inoculations with pure cultures of the organism were made both in the greenhouse and on the Potomac Flats near Washington, D. C. Practically 93 per cent of all the plants inoculated by wounding and inserting spores succumbed to the disease. Successful infections also have been produced by pouring the spores, suspended in water, about the plants.

The disease evidently does not occur on the leaves. Several attempts to infect leaves by spraying and smearing spores on them and then covering the plant for 24 hours or more with bell jars have been unsuccessful.

The organism, however causes a rot of the potatoes or roots. Plants grown on the Potomac Flats near Washington, D. C., and infected by inoculation, were placed when dug in a moist chamber with a part of the stem with roots attached. Pycnidia were abundant on the stems. In less than three months the fungus had grown into the roots and had formed pycnidia on the potatoes. The organism was recovered both from the blackened interior of the decayed potatoes and from the pycnidia. Successful inocu-

lation experiments were conducted with cultures from these isolations. The organism isolated from the roots, besides producing typical symptoms of the disease, compared microscopically and culturally with the original strain.

The foot rot disease is caused by a new species of *Plenodomus*. It is quite evident, however, that it does not fit exactly the description of this genus as laid down by Saccardo¹ or by Diedicke.² It is probable, however, that the fungus is the conidial stage of some ascomycete and its position can, therefore, only be temporary. In view of that fact it is believed better to place it in this genus, where it appears to fit better than any other, rather than to form a new one in a group where there are already a great many. The organism has some characteristics of *Phoma* and *Phomopsis*, but detailed study shows that it is not typical of either of these genera.³ It differs from *Phoma*, (1) in having more irregular-shaped pycnidia with well developed beaks; and

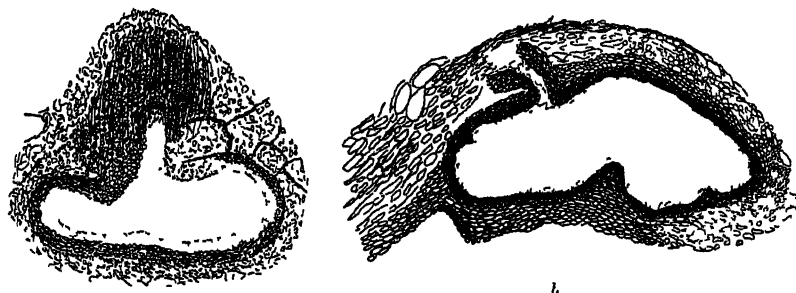


FIG 1. Cross sections through pycnidia: *a*, from root, *b*, from stem.

(2) in having a hyaline inner layer within the pycnidium (fig. 1*a*), especially on the root, but less developed on the stem. The pycnidia on the stem have a very thin hyaline inner layer or none (fig. 1*b*), the basidia then arising directly from the dark or black outer wall. On the potato the hyaline inner layer is well developed, being nearly equal in some cases to the dark outer wall.

The organism differs from the genus *Phomopsis*, (1), in having two instead of four walls composing the pycnidium; (2), in having a dark outer wall which is conspicuous at the top and base of the pycnidia, the outer wall of the pycnidium of *Phomopsis*, which is well developed above,⁴ being practi-

¹Saccardo, P. A. *Sylloge Fungorum* 3: 184.

²Diedicke H. Die Gattung *Plenodomus* Preuss. *Annales Mycologici* 9: 137. 1911.

³The writer is greatly indebted to Dr. C. L. Shear and Mrs. Flora W. Patterson who kindly examined specimens of this fungus.

⁴On the stem the pycnidium of the foot rot fungus is completely enclosed with a dark wall of uniform thickness. On the roots or potatoes the same kind of a dark

cally wanting at the base; (3), in having no chambering of the pycnidium; and, (4), in not being stromatic.

There are no reasons to suspect that this is the same organism which causes the dry rot of sweet potatoes, which has been described as *Diaporthe batatatis*,¹ and whose conidial stage belongs to the form genus *Phomopsis*. Many comparative studies of the two organisms have been made, and they differ widely in their parasitic habits, also microscopically and culturally.

The foot rot fungus differs from any known species of *Plenodomus* in having a thinner hyaline and a thicker outer layer about the pycnidium, in the shape of the conidia (fig. 2a) and the length of the beak.

Frequently there is found in the pycnidium on the host, and sometimes in cultures, straight or curved bodies (fig. 2b), equal to or often greater in number than the conidia, whose function is not known. They are about equal in length to twice the length of the conidia.

A detailed study of the foot rot disease of the sweet potato will soon be published as a bulletin of the Bureau of Plant Industry, United States Department of Agriculture.

The fungus is tentatively described as follows:



FIG. 2. a, Pycnospores, b, Hyaline bodies frequently found in pycnidia.

Plenodomus destruens n. sp.

Pycnidia loosely gregarious, at first buried, later erumpent, very variable in shape, size, and structure, largest diameter about 300 μ , beaked, inner hyaline layer, if present, variable, often wanting; basidia simple, hyaline, fragile, somewhat inconspicuous; conidia oblong, sometimes oval, with rounded ends, 6.8 to 10.0 μ long by 3.4 to 4.1 μ wide, hyaline, continuous, occasionally slightly curved, 2-guttulate.

Hab. On the stems of *Ipomoea batatas*. Type specimens deposited in the herbarium of the pathological collections of the Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

U. S. DEPARTMENT OF AGRICULTURE

WASHINGTON, D. C.

wall encloses the base of the pycnidium, but is often somewhat thickened at the top. For *Phomopsis*, on the other hand, a similar thickening of the dark wall occurs over the pycnidium, but is practically wanting at the base.

¹Harter, L. L. and Field, Ethel C. The ascogenous state of the sweet potato dry rot. *Phytopathology* 2: 121. 1912. See also U. S. Dept. of Agric., Bureau of Plant Industry, Bul. 281. 1913.

BIOLOGIC FORMS OF BLACK KNOT

E. M. GILBERT

Black knot (*Plowrightia morbosa* (Schw.) Sacc. is a very common pest in most every thicket of choke cherry (*P. virginiana*) in Wisconsin. It is so rare as to be almost unknown on pin cherry (*P. pennsylvanica*) and wild black cherry (*P. serotina*), but on the other hand is quite often found on the wild plum (*P. americana*). To date only one case of this disease has been reported on a cultivated variety of plum, and the indications are that this was introduced with the host.

Badly infected choke cherry trees may be found growing in the same thicket with wild plum and yet no trace of the disease will be found on the latter. A grove of wild plums, not far from the University grounds, has within the past three years been entirely ruined by the black knot, while choke cherries whose branches intermingled with those of the plum are entirely free from the disease. Orchards of cultivated plum and cherry in close proximity to badly infested wild varieties are entirely free from black knot. In one orchard, observed by the writer, branches of wild and cultivated cherries were so closely interwoven that it was at first thought that both were diseased, but careful examination failed to show a single knot on the cultivated variety.

As a result of these and other observations it was suggested by Prof. L. R. Jones that it would be advisable, in connection with certain other investigations I was making upon this disease to attempt to determine whether or not the fungus is transferable from one of these hosts to the other. This work has now extended over a period of three seasons and will be continued for at least another year.

As soon as the perfect stage of the fungus reached maturity, which in the vicinity of Madison is from the 3d to the 15th of March, ascospores were obtained in abundance from the choke cherry and the following series of inoculations were made on the wild plum. (1) Spores were sprayed from time to time on the actively growing branches. (2) By means of finely pointed glass tubing, spores were injected into stems at various depths from the cambium region outward. (3) Incisions were made in the bark into which was placed a drop of culture medium containing germinating spores. (4) In other instances, small side branches were partly torn from the main stem and a spore suspension introduced into the wound. Care was taken in all cases of injury to carefully cover the wound with sterilized grafting wax or paraffin to prevent evaporation and to exclude other fungi.

Conidia began to mature about the 20th of April, and when they appeared they were substituted for the ascospores in the experiments. The pycnidial stage of the fungus was found to be extremely variable. Some knots would produce them in abundance while other knots, otherwise seemingly similar, would bear very few. When found in quantity the pycnosporos were used in the same manner as the ascospores and conidia. Stylospores were found in such small numbers that no effort was made to use them for inoculations.

During the season of 1911, spores obtained from the knot of wild plum were used in making a like series of inoculations on choke cherry, but the death of the infected trees did not allow of a repetition of these experiments.

In the spring of 1911, young plum and cherry trees taken from the University orchard were grown in the green house, and ascospores and conidia of both choke cherry and wild plum were used as in the field experiments with an additional spraying at least once or twice a week for several weeks, using spores which had just previously been germinated in the green house.

Black knots found on cultivated varieties of plum, sent to the Department of Plant Pathology from various regions of the country, furnished spores which were used in making a series of inoculations on the wild plum and choke cherry, but as the spores when tested showed a low percentage of germination, the results are hardly worth consideration. Inoculations were also made on the pin cherry, but only in small number, owing to the scarcity of this variety in the neighborhood.

Sterile portions of vigorously growing knots and mycelium from pure cultures were also used in some instances. These were inserted under the bark of the host and carefully covered with grafting wax.

The results of these various experiments may be briefly summed up as follows:

In no single instance was there the formation of any structure which could be compared to the typical black knot.

In many cases small swellings appeared at the place of inoculation, but only such as could have been produced by the mechanical injury.

In a few cases there was a formation of cells loaded with a dense reddish material very much resembling the gummosis found in the normal knot. In some instances there was conspicuous a splitting of the bark.

As a check on these experiments, inoculations were made upon the choke cherry using spores from other choke cherries, and normal knots were obtained from both ascospores and conidia.

Judging from the results of these experiments it would seem that the black knot of the wild plum and the choke cherry are biologic forms and that this may also be true of the forms found to affect the cultivated varieties.

UNIVERSITY OF WISCONSIN

PHYTOPATHOLOGICAL NOTES

Twig canker on black birch. During the winter of 1910 a twig canker was found by Mr. H. W. Merkel to have done serious damage to *Betula lenta* in the New York Zoological Park, New York City, practically killing several large trees. The twigs develop considerable swellings 1 to 2 inches long, and the part beyond the swelling dies. Examination by the Bureau of Entomology revealed no evidence of insect work. *Sphaeropsis* sp., closely resembling *Sphaeropsis malorum* except by its somewhat smaller spores, was generally distributed on the dead twigs. Fungi referred to *Cytospora* sp. and *Myxosporium* sp. were also isolated. Parasitism of the three fungi was tested by placing agar bearing mycelium from pure cultures, in slits in the bark of twigs of *Betula lenta* which were starting growth in water culture. Check twigs were inoculated in the same way, using sterile agar. The results at the end of forty-one days were as follows:

Sphaeropsis: 15 twigs inoculated, all girdled.

Cytospora: 10 twigs inoculated; two girdled, two partly girdled, six uninjured.

Myxosporium: 10 twigs inoculated; two nearly girdled, eight uninjured.

Checks: 10 twigs; none injured.

Except in one or two cases of twigs very recently girdled, the leaves beyond the points of girdling were dead. In no case was there any swelling of the twigs.

A month and a half later young trees of *Betula lenta* recently potted in the greenhouse were inoculated with these fungi, and in addition with a culture of *Sphaeropsis malorum* obtained from Mr. J. W. Roberts. Six incisions were inoculated with the *Sphaeropsis* from birch, five with each of the other fungi, and five with sterile agar. In each case three inoculations were protected by wrapping with wet cotton, and the rest were left open. The results were negative in all cases.

These tests are taken as an indication that the *Sphaeropsis* from birch has parasitic ability only under certain conditions. It also appears that twigs growing in water culture are much more susceptible to this parasitism than stock rooted in soil. Further tests are necessary to confirm these points. While the twigs in both experiments were just beginning spring growth, the conditions differed in that different agars were used as inoculum in the first and second tests, and the first test was conducted under a bell-jar, while the second was not so covered and could not be kept as constantly moist.

The twig canker disease at the New York Zoological Park has practically ceased spreading, and has not been elsewhere reported. It is not probable that any of the fungi mentioned in the foregoing were concerned in causing the swollen cankers characteristic of the disease.

CARL HARTLEY

Bark rusts of Juniperus virginiana. The following preliminary observations were made by the writer mainly in the vicinity of Washington, D. C., in 1909 and 1910. The three commonest cedar bark rusts in the District of Columbia appear to be *Gymnosporangium clavipes*, C. and P., *G. nidus avis* Thaxt. and *G. effusum* Kern (identifications by F. D. Kern), the first named being the most abundant. A peculiar physiological character of *G. clavipes* makes macroscopic distinction between it and the other two species very easy. *G. clavipes* has the peculiar habit of growing faster across the grain than with it. After once seeing the lesions produced by this species one can easily recognize them at any time of year. Both of the other species grow from six to eight or more times as fast longitudinally as they do transversely. A single trunk lesion 6 feet 8 inches long has been observed, and the lesions of *G. nidus avis* on the branches are often much longer, while the lesions produced by *G. clavipes* seldom exceed a foot in length.

The long type of lesion on trunks commonly attains considerable age. An old lesion on a dead trunk, evidently produced by either *G. effusum* or *G. nidus avis*, had continued to extend for thirty-two years after the bark died at the center of the lesion, as shown by counting annual rings. Since the bark at the center of a lesion lives for some years after infection, the colony of the parasite causing the lesion presumably lived at least forty years. Many lesions on older trees appear older than the one which the writer had opportunity to examine.

It is difficult to tell how much damage these three rusts do. *G. clavipes*, found very commonly on bark of all ages, seems to kill many isolated twigs. In some cases one or more of these bark rusts seem to be partly responsible for the death of lower branches common near Washington, Baltimore and elsewhere. They do not seem to be the main factors in causing the general unhealthy condition of cedar in these neighborhoods.

CARL HARTLEY

Quince blotch and apple fruit spot. In the fall of 1912 the writer secured badly spotted specimens of the fruit of the Chinese quince, *Cydonia sinensis* Thoun. from Maryland. Isolations from these spots always produced pure cultures of *Phoma Pomi* Passer (*Cylindrosporium Pomi* Brooks). Obtaining this fungus on the above host in America is of particular interest

since this is the species of quince upon which Passerini described *Phoma Pomi* in Italy. Further evidence of the identity of the American and Italian species is thus furnished. The spots on the Chinese quince had the same speckled appearance as on *Cydonia vulgaris* Pers. but had more brown color than those on the latter host. No fruiting bodies of any sort were found on the above quinces, but the behavior of the fungus in culture left no doubt as to its being identical with that from apples and from other species of quinces.

Information obtained during the past year shows the *Phoma* fruit spot of apples to have a much wider distribution than has been reported in earlier publications. In the summer of 1912 the disease was of general occurrence in North Carolina, Ohio, Virginia, and West Virginia.

CHARLES BROOKS

Notes on cultures of three species of Peridermium. From field observations made on *Peridermium inconspicuum* Long, occurring on *Pinus virginiana* Mill., the junior author was convinced that this *Peridermium* had its alternate stage on species of *Coreopsis*. Sowings of aeciospores were made under greenhouse conditions on *Coreopsis verticillata* L., May 12, 1913, and May 27 uredinia appeared chiefly on the upper surface of the leaves. Every plant in the ten pots used in the experiment was infected, while the check plants were free of rust. Sowings were also made at the same time with an abundance of aeciospores on plants of three species of *Solidago* and on ten plants of *Helianthus divaricatus* L., but no infection occurred. The *Coleosporium* on *Helianthus* and the one on *Coreopsis* do not therefore seem to be identical. For this reason the name *Coleosporium inconspicuum* (Long) comb. nov. will be used for this rust on *Coreopsis*.

The senior author has for two years been making cultures with *Peridermium delicatulum* Arth. & Kern from *Pinus rigida* Mill. From field observations he was certain that the alternate stage occurred on species of *Solidago*. Sowings of aeciospores under greenhouse conditions were made on a number of species of *Aster* and *Solidago*. Sowings of aeciospores were made on *Euthamia graminifolia* (L.) Nutt. (*Solidago lanceolata* L.) on May 28, 1913, and on June 13 uredinia appeared on both sides of the inoculated leaves. The urediniospores are usually characterized by a thickening of the wall at the apical end, similar to the description given for the urediniospores of *Coleosporium vernoniae* B. & C., but as no cultural proof is at hand concerning the identity of these two species, the one on *Euthamia* will take the name *Coleosporium delicatulum* (Arth. & Kern) comb. nov.

Successful cultures were also made with *Peridermium stalactiforme* Arth. & Kern from material on *Pinus contorta* Loud. collected by Dr. J. R. Weir in Idaho. The sowings were made on *Castilleja linearis* Rydb., June 9,

1913; uredinia appeared June 20 and telia July 1. This confirms the work reported done by Dr. E. P. Meinecke in 1912 (Phytopathology 3: 167. June, 1913). In a later article the writers will discuss in full the cultures here described.

GEORGE G. HEDGCOCK
W. H. LONG

An undescribed species of Peridermium from Colorado. During recent collecting trips made by Prof. E. Bethel in Colorado, he found several species of Peridermium. Among these was an undescribed caulicolous form on *Pinus contorta* Loud. (*P. murrayana* "Ore. com.") which according to Professor Bethel had certain gross characters sufficiently well marked that it could be distinguished even in the field from the other species of Peridermium collected on this trip. In a later communication Professor Bethel called attention to the pyriform aeciospores, so typical of this new species. The following is a description of the fungus made from fresh material:

Peridermium betheli sp. nov.

Pycnia unknown.

I. Aecia caulicolous, not forming definite swellings, scattered, or somewhat confluent in small groups, rounded or irregular, 2 to 6 mm. long by 2 to 4 mm. wide by 1 to 2 mm. high, peridium bladdery, subhemispherical, rupturing irregularly along the top and sides, concolorous processes entirely absent, about two cells thick, outer surface minutely and rather closely verrucose, inner rather closely verrucose with somewhat longer tubercles than the outer wall, margin of peridial cells radially striate, walls thin, 2 to 4 μ thick, lumen large, peridial cells rounded, elliptical or oblong, not readily separating from each other, those of inner layer often irregularly compressed. Cells composing top of aecium roundish, 15 to 30 by 22 to 42 μ , cells of lower portion elliptic to oblong 16 to 20 by 40 to 60 μ .

Aeciospores ovoid, ellipsoid, lemon shaped to pyriform, usually strongly acuminate at one end, more rarely at both ends, very variable in shape and size, walls colorless, thicker at both ends than in middle, 3 to 4 μ thick, minutely and rather densely verrucose with small irregularly shaped tubercles, which in the narrow ellipsoid spores are arranged in irregular parallel lines, or with ridgelike markings which give the surface a reticulated appearance. No smooth spot present, spores 15 to 25 by 25 to 48 μ , average size for 10 spores 21 by 38.5 μ , occasionally very large sub-globose spores about 38 by 48 μ in size.

The most marked characteristic of this species is its acuminate pyriform aeciospores. The peridial cells are markedly coherent, the outer layer

seems to be composed of cells with a very short radial diameter while the cells of the inner layer are thicker. This species does not produce galls, or marked hypertrophy of the host.

Collected by E. Bethel on twigs, limbs and trunks of *Pinus contorta* Loud. Eldorado, Colorado, July 12, 1913, near Allenspark, Colorado, June 21, 1913, and near Arrow, Colorado, July 1, 1913. The range of this fungus is doubtless extensive, but hitherto it probably has been confused with *Peridermium harlnessii* Moore.

GEORGE G. HEDGCOCK
W. H. LONG

An epidemic of needle diseases in Idaho and western Montana. Up to the present time very few reports have been made of *Lophodermium pinastri* (Schr.) Chev. as an epidemic disease in American forests. In the forest regions of western Montana and northern Idaho this fungus, owing to the excessive rains and short cool summers of the past few seasons, is rapidly becoming a serious menace to young western white pine, and in some regions to yellow pine as well. The fungus has always, as it seems, played a prominent rôle in hastening the suppression of trees in high forests, but only in the last season or two has it begun to attack trees of all ages. So virulent is its epidemic nature that in many regions the youngest needles of the season are attacked and succumb to the disease, bearing ripe apothecia by June. White pine stands in moderately deep ravines uniformly turn brown and appear from a distance as if scorched by fire. Trees from thirty to fifty years will have every needle from crown to lowest branch infected. The disease has not yet appeared in the forest nursery, but it is a very common cause of death of young seedlings in the forest. A study of sample plots in the Priest River Valley gave the result that as high as 50 to 70 per cent of the young white pine succumbed to the disease. On the Kootenai forest (Libby, Mont.), North and South Fork of the Coeur d'Alene River, Coeur d'Alene National Forest, and in the valley of the Pend Oreille River the disease is doing great injury to white and yellow pine. It is hoped by another year its ravages will have become less.

In the Priest River Valley for the past three seasons a needle-cast fungus of the Larch has assumed an epidemic nature. Last year the trees of many young larch stands of twelve to fifteen years were completely divested of their needles; the second crop of needles of the season was likewise killed.

The foliar spurs that suffered destruction of needles last year are only now (June 24) beginning to send out the season's growth, while the healthy spurs bear the normal size and number of needles. The epidemic nature of the fungus is remarkable. Needles as they emerge from the foliar spurs are attacked and killed. Entire young shoots are killed in many instances. The

increment of infected trees is falling off. At the highest range of the larch the fungus is not found. There is great danger of an invasion of bark beetles, owing to the weakening influence on the trees of these needle diseases.

A close study is being made of these diseases, the results of which will appear later in the year.

JAMES R. WEIR

Personals. Dr. F. D. Kern, recently associate botanist of the Indiana Experiment Station, has been elected professor of botany in the Pennsylvania State College.

Guy West Wilson has accepted a position as agent in the office of forest pathology, Bureau of Plant Industry. He will be engaged in studies of the chestnut bark disease, in cooperation with the New Jersey Experiment Station. His address is New Jersey Experiment Station, New Brunswick, N. J.

At the recent meeting of the American Medical Association in Minneapolis, Dr. Erwin F. Smith was awarded a Certificate of Merit in recognition of the value of his work on crown gall in relation to human cancer.

Mrs. Nellie D. Morey, of the University of Wisconsin, has been appointed xylotomist in the Bureau of Plant Industry, to assist in potato disease investigations.

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THE PATHOLOGICAL ANATOMY OF POTATO SCAB

B. F. LUTMAN

WITH TEN FIGURES IN THE TEXT

Although potato scab is widespread in this country and Europe, occurring every year in abundance, the only phase of the disease that has been at all extensively studied is that of methods of prevention. The lesions produced by the disease are so characteristic and involve such unique tissue changes that the pathology of scab has a general botanical interest.

As has been shown by Kny, Massart (9), and Olufsen (10), the periderm of the potato is regenerated with the greatest ease from any of the cells of the starch parenchyma. It is not even necessary, according to Massart, to remove the cork layer nor to kill the cells in order to stimulate the cells underneath the cork to divide to form a new cork layer and he was able by simply applying pressure to induce the formation of a new cork layer under the old uninjured one.

The disease known as "scab" is now believed to be due to organisms in the soil, which, acting on the cork cambium, stimulate it to hyperplasia and hypertrophy.

Bolley (2) isolated from the tissue under the lesions a true bacterium which, on inoculation, would produce the disease. These bacteria were rods, 1μ by 7μ in fresh cultures, but in tubes that had been kept for some time, they had rounded up into cocci, 7μ to 8μ in diameter. These cocci had approximately the same dimensions as the spherical bodies he was able to observe in the cork cambium and the underlying starch parenchyma cells.

Thaxter (11) isolated from scabby potatoes in Connecticut a filamentous organism capable of producing scab on inoculation. He classified this organism with the lower fungi (Oospora).

Bolley (3) working in North Dakota (his previous investigations had been conducted at Lafayette, Indiana) was not able to repeat his Indiana isolations and inoculations of a bacterium but found an organism closely resembling that of Thaxter's, always associated with the scab.

Cunningham (4) has proposed taking the Thaxter organism out of the true fungi and classifying it with the soil Streptothrices to which it seems to be more nearly related.

It is still in some measure a matter of question as to whether all forms of scab are due to the same cause and involve essentially the same pathological conditions, or whether under the general designation of scab we are really dealing with a group of diseases possibly caused by distinct organisms.

Humphrey (7) has endeavored to divide the American disease into superficial scab and deep scab, although he admits "that the causes determining the development of the deep form are wholly indefinable."

Frank and Krüger (6) claimed to be able to distinguish gross morphological differences in the scabs found on the German potatoes. These varieties of scab were named, (1) shallow scab (Flachschorf), (2) deep scab (Tiefschorf), (3) bulging scab (Buckelschorf), (4) bulging deep scab (Buckeltiefschorf). These distinctions, however, are probably between different stages in the advance of the same disease rather than between scabs produced by different organisms. According to my own observations, the German and American scab are the same disease and do not warrant any division into definite groups, as the intermediate stages between such classes are too numerous and represent all gradations.

No detailed account, with figures, of the origin and growth of the scab tissue seems to have been published, although Frank (5) and Bolley (2) give one or two semi-diagrammatic drawings of sections of old scabs. The pathological tissue changes are entirely different in the "wart" disease due to *Chrysophlyctis endobiotica* although at times there might be a superficial resemblance, in its external appearance, to that of the scab. The pathology of true scab is only concerned with the cork layer, the cork cambium, and an underlying thin layer of starch parenchyma.

My method in the following work was to fix young potatoes, or small pieces of potato containing scab, in Flemming's weaker solution, imbed, section, and stain. Practically all the results are from such sections. The potatoes used were of the Green Mountain variety. The earliest stages of scab recognizable as such, had a diameter of 0.5 mm. The staining was done either with safranin alone, safranin followed by haematoxylin, or safranin followed by gentian violet. The suberised walls of the cells stain red with any of these combinations, while the cellulose ones are either colorless or purple. In addition to the sections, glycerine mounts of potato skin containing young scabs were examined.

The development and structure of the corky layer enclosing the potato tuber is very simple. The cork is already 6 to 10 cell layers thick, with the cells arranged in rows, when the young tuber is only a small white terminal bud of the size of a pea. There seems after this initial growth to be very little increase in the number of cell layers although the growth of the surface area of the cells must be continued in order to provide for the

enlarging tuber. The suberisation of the walls is not very marked, as shown by the staining reaction, until the tuber itself begins to turn brown. Figure 1 is from a section of the cork of a tuber of the size of a hulled walnut. The epidermis at this time often cannot be distinguished from the underlying cork cells. The innermost cells of the cork constitute the most active dividing layer, if their thickness is an indication. Under the cork layer is the starch parenchyma, the outer cells of which, as a rule, do not contain very much starch.

The first lenticels are to be seen as white spots on the tuber when the latter reaches a diameter of a centimeter. They increase in number during the early stages in the growth of the tuber, the new ones being formed between the old ones.

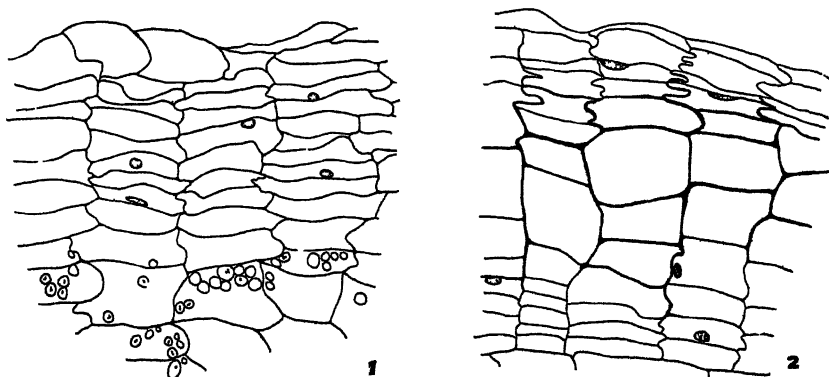


FIG. 1. Section of normal potato periderm. $\times 150$.

FIG. 2. Section of a young scab. $\times 150$.

It is very difficult to distinguish much detail, even under the low power of the microscope, in the unstained glycerine mounts of the corky layer containing the youngest recognizable scabs. The enlarged, thick-walled cells of a layer lying beneath the cork can, however, be made out. I can find no evidence to support the statement of Frank and Krüger (6) and Humphrey (7, p. 219) that the scab always takes its origin in a lenticel, although lenticels often appear in the young scabs, and the lenticels would be the portion of the periderms through which the invasion of foreign organisms into the deeper tissues would seem to be easiest. If a lenticel is always the center of infection its tissue must change rapidly, as it cannot be recognized in many very young scabs. It should also not be overlooked that on practically every tuber there are patches of brown apparently dead cells in the periderm on which the fungus grows (as discussed in detail later) but we have no evidence that actual penetration of the outer layers is necessary.

Sections show the relation of the parts much more clearly (figs. 2 to 5). The cork layer seems to be split at this time by a varying number of hypertrophied cells into two strata, the innermost of which is usually the thicker. The thin-walled cells of both layers are rich in protoplasm and contain large nuclei. The walls of these cells, as shown by their staining reaction, are apparently pure cellulose. Those cells showing hypertrophy to any extent have at least some walls that are suberised and thickened, while those that have greatly hypertrophied have walls many times thicker than those of the strata of cork. This thickening and suberisation frequently does not affect all the six walls, and one or more are left thin and composed of cellulose. This increase in thickness apparently has no relation to the position of the nucleus in the cell. The amount of protoplasm in hypertrophying cells diminishes and in the larger ones with

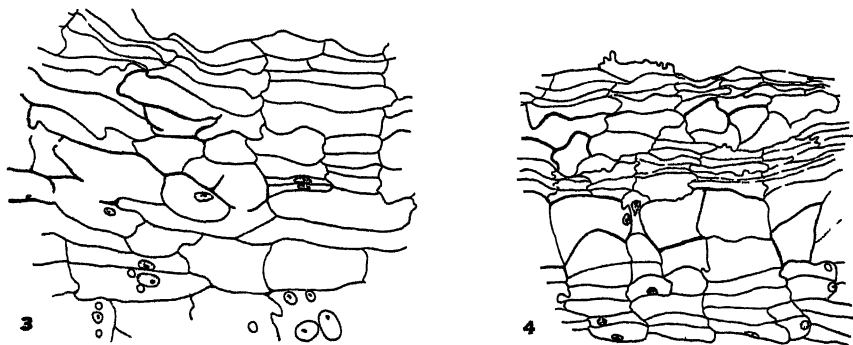


FIG. 3. Section of a young scab near its margin, normal tissue to the right. $\times 150$.

FIG. 4. Section of a young scab showing stratification in the periderm, due to the alternation of hypertrophied and normal cork cells. $\times 150$.

thick walls has entirely disappeared. The nuclei, as compared to those of the cork cambium, do not seem to hypertrophy, the size of the nucleus being dependent, not on the size of the cell itself, but on the quantity of protoplasm and on its activity in growth and division.

Figure 3 shows a section through the margin of one of the very young scab spots; to the right is normal tissue, to the left are the hypertrophied cells. The very characteristic manner in which the suberised walls break in sectioning is also shown by this drawing. The walls seem to splinter into fragments, like glass, under the stroke of the knife. Part of the breaks, especially in old lesions, may be due to tensions on the cell walls, but in the younger scabs they are the results of the razor shattering the brittle walls. All the drawings, except figure 3, are diagrammatic in that these broken walls are shown as they would naturally appear in the tuber.

In many instances the hypertrophy, instead of affecting only one layer, involves two or more, as in figure 4. The cork cambium in this section is split into three strata; an outer and a middle one in which the cells do not continue to increase in numbers to any extent, and an inner one in which cell divisions are apparently still numerous. Frank in his *Kampfbuch* (5) has a figure of a scab section in which there are four of these layers of cork cambium. The downward growth of the scab tissue would seem to be due to the repeated regeneration of the cork cambium. The stimulation of the fungus growing on the surface of the scab spot causes the cells of the cambium to hypertrophy. Almost immediately a new cambium is regenerated from the outermost of the unaffected starch parenchyma cells. The hypertrophy of the cork cambium layer seems to produce the same results as was obtained by Massart (9) by the application of pressure. The stimulus in the present case may be the same, or more probably is the result of the absorption of toxic substances produced in the growth of the parasitic fungus on the exterior.

Continued regeneration, in the method described, carries the scab tissue deeper and deeper into the tuber, as during this time the potato is continuing to grow where it is unaffected. In general, therefore, it would be expected that the very deep lesions resulted from an infection when the tuber was young. Deep scabs might, however, be produced on fairly large tubers if the conditions for the growth of the organism producing the stimulus continued always favorable. In connection with this point, the number of times the regeneration occurs is of interest. The parasitic organism on the lesion undoubtedly grows best in wet weather, possibly remaining practically quiescent when the soil is dry. There is a strong possibility, therefore, that the number of hypertrophies corresponds to the number of periods of renewed activities of the fungus, due to periods of wet weather with the resulting damp soil.

Frank and Krüger (6) claim that in *Buckelschorf* the outer layers of starch parenchyma are stimulated to hypertrophy, but I have never observed in any of the ordinary forms of scab an abnormal growth of parenchymatous cells, except in the manner described.

In some cases there are produced scabs of a diameter of a half a centimeter (fig. 5), but with only one regeneration of the phellogen. The cells of the outer portion of the cork cambium seem to increase in numbers while they become flattened and develop thick suberised walls. This outer strata, with the thick-walled, nearly empty hypertrophied layer placed between it and the food being stored in the potato, cannot be highly nourished and growth in it cannot continue indefinitely.

In the section of a very old scab, such as is shown semi-diagrammatically in figure 6, the diseased tissue has continued to thicken until a layer of

a half centimeter sometimes results. At the edges of such a lesion can usually be seen the turned up edges of the old outer cork layer, and lying on top are still some of its remains. A cork cambium extends under this diseased tissue, cutting it off from the starch parenchyma beneath. In the scab tissue itself can often be traced the remains of the regenerated cambium with the intervening layers of hypertrophied cells.

No nuclear divisions were observed in any of the sections examined. Growth in the abnormal tissue is necessarily slow and many divisions are

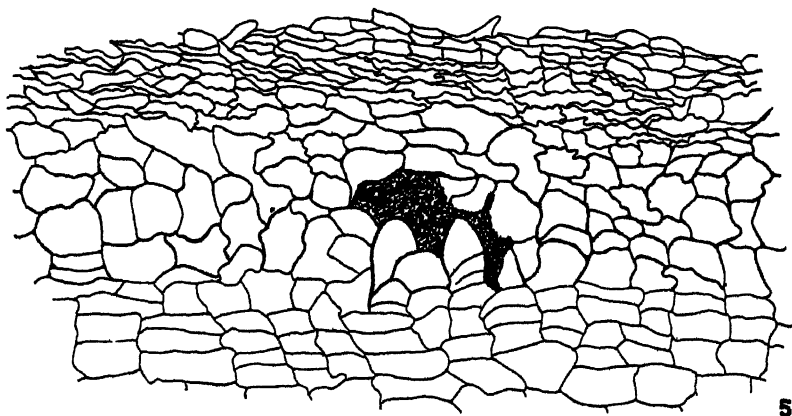


FIG. 5. Section from an older scab. $\times 200$.

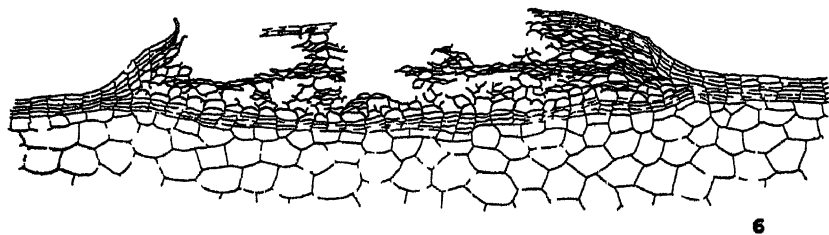


FIG. 6. Semi-diagrammatic drawing of section of an old scab.

not to be expected. The nuclei are normal in appearance in the young hypertrophied cells, although they disappear in the older ones. I am able to confirm Bolley's (2) statement that the starch grains in the parenchyma underlying the scab spots are unaffected. Instead of the starch being deposited in the form of grains and then redissolved to make cell walls, the carbohydrate material seems to be used directly, without the formation of starch grains.

THE ORGANISM IN THE TISSUES

Bolley (2) figures in the cork cambium and the underlying cells of the starch parenchyma bodies which he believed were the causal organisms. These were spheres of a diameter of 0.007 to 0.008 mm. In his later work (3), when he had come to consider the Thaxter organism as the cause of the disease in North Dakota, he published a drawing of a cork cell with this fungus in it. It appears as a "filamentous ramification of the parasite in the cells and aggregate masses of septated portions of the same in the corners of the cells."

Thaxter (11) does not mention having seen the organism in the tissues although it was externally present as a gray, mould-like deposit along the edges of the younger spots.

So far as I have been able to observe no fungi nor bacteria were present in any section examined. My inability to locate any traces of the causal organism is not to be interpreted as meaning that it is not in the diseased tissues. The apparent absence in sections of such parasitic invasions may be due to the comparatively small growth of the stimulating mycelium, to its growth only under certain conditions and its disappearance at other times, to the difficulty of distinguishing the very fine thread-like mycelium in thin sections, or to the lack of staining properties of the threads.

While it is so difficult to distinguish mycelium in sections, it can be seen sometimes in a surface view of the periderm. In unstained glycerine mounts of the corky layer of young scabby potatoes from damp, rich garden soil there may often be seen (fig. 7) patches of cells whose walls are browned. An examination of these always reveals the fact that the walls are crossed by numerous fine branching lines of about the same thickness as the walls themselves, and often difficult to distinguish from them. No such lines appear in the clear, unstained cells. These lines correspond in size and appearance to the hyphae of the organism found by Thaxter (11) to produce scab. The organism imbedded in this tissue, if not the same as Thaxter's, certainly belongs in the same group and is associated, as was his, with the development of scab. The distribution of these hyphae is very irregular, occurring on any part of the potato, but always in the outer layer of the periderm. The browning of the walls of the host cells seems to be due to the growth of the fungus, as under the narrow hyphae a broader stain of brown often shows.

Beijerinck (1) found that he could isolate from the roots of various ferns, shrubs and trees an organism (*Streptothrix chromogena*) which seems, according to his description, to agree fairly well with the one so abundant in the outer layers of the potato periderm. These organisms were im-

bedded in the tissue of the roots, as Beijerinck was able to show that they could be found in nearly pure cultures if the roots were first thoroughly washed before being macerated and plated out. They occur, however, also in the soil surrounding the roots, but in fewer numbers. In cultures, the organism browned the media. On account of the organism's almost universal occurrence, he states that it is always a saprophyte, never a parasite.

The organism found in the cork of the potato is undoubtedly the same as that described by Beijerinck, but as all stages of browning, and also the young scabs, contain it, it would seem to be pathogenic on the potato under certain conditions.



FIG. 7. Surface view of cork cells showing the distribution of mycelium in the cells. $\times 160$.

FIG. 8. Section of phellogen; cells show fat globules of various diameters. $\times 190$.

Although neither fungi nor bacteria were visible in sections of the diseased tissue, there are often to be observed in the cells of the cork cambium and in those of the parenchyma immediately under it, great numbers of small bodies which stain red with safranin in the safranin-gentian violet combination. The presence of these bodies in the cells is not invariable, but they are more frequent under old scabs. There can be no question but that these are the same bodies observed by Bolley (2) and considered by him to be the organisms which produce the stimulus resulting in scab. Their position is the same as those found by him and their general appearance, to judge from his figures, is similar. His observation that they were in motion in sections cut from living tissue may be true, but the motion was probably Brownian and not a vital one. As shown in figures 7, 8 and 9, there are great numbers of these globules, and they vary in size from fairly large droplets to ones so small that it is

difficult to see them with the oil immersion lens. It is also to be particularly noted that all the intermediate sizes are to be found.

The chemical nature can be made clear at once by an examination of unbleached sections from material fixed in Flemming's solution. All sizes retain the dark brown color characteristic of fat globules stained with osmic acid.

The starch seems to be lacking in the parenchyma tissue immediately under scabs. No evidence of corrosion of the grains was to be seen and the inference is that they were never formed, the fat droplets just described serving as a substitute form of carbohydrate storage. This transformation into fat is probably only a transitional stage to its deposition in the walls of the hypertrophied cells. Suberisation, according to the

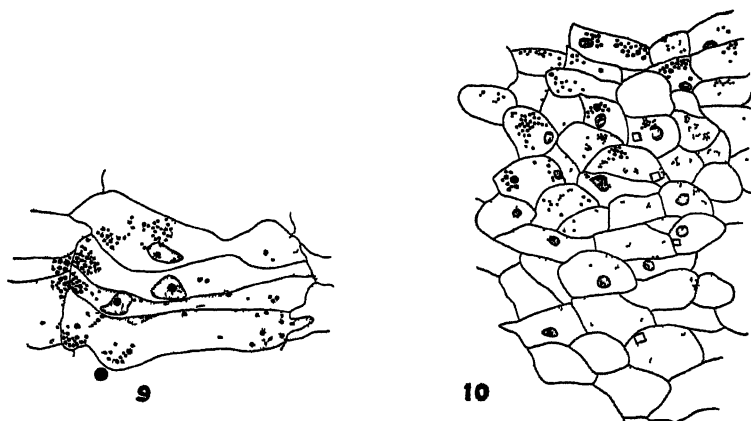


FIG. 9. Same as figure 8, but section of the outer layers of the starch parenchyma. $\times 225$.

FIG. 10. Section of starch parenchyma showing the size and distribution of the fat globules. $\times 200$.

accepted view (Van Wisselingh, 13) is an impregnation of the cell wall with glycerine esters, or substances related to them. The fatty substances deposited in the cells as globules are immediately available for deposition in the cell walls, although they may first undergo some chemical changes.

The presence of fat, instead of starch, in pathological plant tissue must be of frequent occurrence, although I find no reference to it in the literature. Küster (8) mentions the frequent accumulation of abnormal amounts of starch in diseased cells but cites no instances where fat droplets occur. In the present case, these globules serve an immediate purpose and may be considered as one reaction of the tuber in its efforts to exclude the parasite attacking it.

SUMMARY

1. The scabs may originate at any place on the potato, but frequently occur at lenticels.

2. The scab is due to the hypertrophy of the cells of the cork cambium. This condition is always accompanied in deep scabs by a hyperplasia of that layer, due to its continued regeneration from the outer cells of the starch parenchyma. The walls of the hypertrophied cells are much thickened, due to their suberisation.

3. In surface view of brown spots on the skin of scabby potatoes and in very young scabs, there can be seen in glycerine mounts, the thread-like filaments of the fungus which apparently produces the disease.

4. There occur in the cork cambium and in the outer layers of the starch parenchyma, instead of starch grains, great numbers of fat globules of varying size. These bodies are one of the results of the disease. The carbohydrate material is stored in the tissues affected by it in this form.

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IS APPLE SCAB ON YOUNG SHOOTS A SOURCE OF SPRING INFECTION?

W. J. MORSE AND W. H. DARROW

It is generally conceded by phytopathologists that the apple scab fungus, *Venturia pomi* (Fr.) Wint., in addition to occurring on the leaves and fruit, is at times parasitic upon young branches and water shoots and in this relation, particularly in the case of susceptible varieties, may be the source of considerable injury. There does not appear to be such a unanimity of opinion among European and American writers as to the part which this phase of the disease plays in the inception of the attack the following spring.

Sorauer¹ in discussing the manner in which the fungus passes the winter mentions first the infected branches and then the perithecial stage upon fallen leaves, and even goes so far as to state that the fungus may live over on the sound growth and become a source of infection the following spring. Massee,² in a recent text-book, while he describes the ascigerous form of the fungus, does not mention it in any way whatever as the source of spring infection. His position with regard to the importance of the diseased shoots is shown by the following quotations.

"In early spring infected shoots are readily recognized by the much injured bark or skin which is frequently torn into shreds, more especially near the base of last year's shoot. At this period of the year the exposed blackish patches are densely covered with the *Fusicladium* form of the fruit which is carried by wind, rain, etc., on to the young leaves, which become infected. . . . From the above account it will be seen that the young apples are mostly infected by spores produced on the leaves. But the leaves could not become infected except by spores produced on diseased shoots, consequently diseased shoots are the source of all the mischief.

."

In another recent article Voges³ has also claimed that the apple scab fungus lives over winter on the twigs and is thus a source of infection of the young leaves and fruit in the spring. On the other hand, Aderhold⁴

¹ Sorauer, Paul. Handbuch der Pflanzenkrankheiten. 2: 249. 1908.

² Massee, George. Diseases of cultivated plants and trees, p. 206. 1910.

³ Voges, Ernst. Die Bekämpfung des *Fusicladium*. Zeit. für Pflanzenkr. 20: 384-393. 1910.

⁴ Aderhold, Rud. Die *Fusicladien* unserer Obstbaume, II. Landw. Jahrb. 29: 541-587. 1900.

in 1900, after many years of observation, while noting the frequent occurrence of pear scab on young twigs, particularly in nurseries, and emphasizing this as an important factor in carrying the disease of pears over winter, states that only two cases have come to his attention where apple limbs were so attacked. This leads one to infer that he considers this form of the disease on apple as of no importance as a source of spring infection.

So far as the writers of the present paper have been able to learn, little evidence has been obtained in this country in support of the position that diseased twigs are important factors in carrying the apple scab fungus over winter. According to Clinton⁵ the spores of the *Fusicladium* stage probably do not retain their vitality for any considerable period of time. In one instance he found the fungus occurring on the young growth of a badly infested crab apple tree. The following spring a thorough examination of the twigs failed to show any sign of the fungus on them. During three years of observation in Illinois he did not find any evidence that the diseased twigs were a source of infection the following year in that state.

A few years later Lawrence in Washington made a somewhat similar series of observations and experiments and came to the conclusion that the fungus was not carried over winter by the summer spores.⁶ In this connection it may be mentioned, however, that the ability of the fungus to live over winter on the diseased branches does not necessarily depend upon the viability of the spores produced the season before. Some have suggested the possibility of the mycelium remaining alive in the attacked twigs during the winter and being in a condition suitable for very early production of conidia the following spring.

Conditions during the growing season in Maine were probably more favorable for the development of the apple scab fungus in 1912 than for several years previous. Consequently a large amount of damage was recorded on both fruit and leaves throughout the state. Early in the following winter specimens of young apple branches attacked by scab began to come to this station from correspondents in various parts of the state.

The trouble seemed to be so general and widespread and the opportunity to secure data on the point mentioned above seemed so favorable that arrangements were at once made to secure specimens of apple twigs so attacked from as many and as widely separated sections of the state as possible. In this connection the writers wish to acknowledge their indebtedness to State Horticulturist, A. K. Gardner, and Assistant State

⁵ Clinton, G. P. Apple scab. Ill. Agr. Exp. Sta. Bull. 69. 1902.

⁶ Lawrence, W. H. Apple scab in western Washington. Wash. Agr. Exp. Sta. Bull. 64. 1904.

Horticulturist, H. P. Sweetser of Augusta, as well as to Mr. George A. Yeaton and Mr. Arthur L. Deering, County Directors of farm demonstration work for the University of Maine College of Agriculture in Oxford and Kennebec counties, for valuable assistance in securing many of the specimens studied. These specimens were obtained from Androscoggin, Kennebec, Oxford, Penobscot, and Waldo counties, representing a considerable portion of the apple growing section of the state.

The affected branches showed very few of the characteristics described by Massee. While the bark was frequently affected near the tip, in many cases the diseased area began one or two or even three inches back on last year's growth and extended back from one to several inches. There was no tearing of the bark into shreds, but it was more or less thickly studded with light brown spots. Scattered spots were, as a rule, oval to elongate in shape, although frequently nearly circular, and were usually not more than a millimeter in diameter. Quite often, however, in severe cases these spots ran together, forming a diseased patch of considerable area which appeared as a scurfy coating on the young bark.

Closer examination of the light brown spots showed that they were blister-like pustules resulting from the death and pushing out of the epidermis. In the center of each pustule was a blackish portion composed of the olive-colored conidia of the fungus.

A detailed study of the conditions in the field were made by the junior writer in the vicinity of Orono. This was of necessity somewhat limited, as the location is outside of the best apple growing district of the state. It was observed that strong-growing water sprouts were more badly affected than young growth on the ends of branches. Water sprouts two or three feet long were often diseased for the last foot or more of their growth. Also the more vigorous growing twigs at the ends of the branches were the more severely attacked. Those which showed but little elongation were only slightly infested, or not at all.

In an orchard containing seven varieties, McIntosh and Fameuse were the worst attacked. Mildred and Westfield ranked next in order of susceptibility. Only an occasional twig was found to be affected on the Northern Spy trees and these but slightly, while the Oldenburg and Tolman trees were entirely free from injury.

In the majority of cases the pustules on the affected twigs contained numerous *Fusicladium* conidia. Many of these spores were found to germinate readily in prune decoction and in prune agar. These germinations were made at various times during the latter part of the winter and early spring up to about the first of May, or till about the time the leaf buds began to open. Pure cultures were made by means of prune agar, and the fungus was grown upon a variety of culture media in comparison

with an authentic culture of *Venturia pomii* isolated from apple fruit. These agreed in every respect.

Young apple trees growing in the greenhouse were then inoculated by spraying the foliage with spores produced in cultures of the fungus from apple limbs. They were covered for a short time by large, glass bell-jars to secure a moist atmosphere and at the end of a month or 6 weeks the leaves of the trees so inoculated were badly attacked by apple scab. Scab did not develop on other young trees in the greenhouse which were not inoculated.

Voges, as mentioned above, places much emphasis upon the diseased twigs being an important means of the overwintering of the fungus and maintains that the mycelium itself exists on the diseased branches as a living stroma which begins to vegetate early in the spring and to produce conidia, often as early as March. Our studies do not throw any light upon this phase of the matter. It is true that in several instances diseased branches were received where no spores were found within the pustules. These, however, were collected and sent in by correspondents at some distance from the laboratory making it impossible to carry on further studies upon the trees from which the specimens came. A large part of the spore germinations and local collections were made after the first of March. While it is possible that some of the later germination tests in April were made with spores recently produced, it does not seem probable under the climatic conditions which prevail in this state, that the fungus would be sufficiently active to fructify early in March.

From the above it would seem evident that in this climate it is perfectly possible for the apple scab fungus, and the conidia of the same, to live over winter on diseased twigs and water sprouts, and that this form of the disease may be an important factor in the production of early spring infection where susceptible varieties of trees are grown. In this connection it is a matter of extreme practical importance to know how effective a dormant spray of bordeaux mixture or lime-sulphur is in controlling this phase of the disease. In the laboratory it was found that simply dipping the affected twigs for a few seconds in the winter strength lime-sulphur sufficed to kill all living spores, but no results of a regularly conducted spraying experiment were secured. However certain observations made by the senior writer furnish some rather interesting data upon this subject.

These observations were made upon a block of four-year-old McIntosh trees in an orchard in the western part of the state. This consisted of 40 trees, five rows of eight trees to the row, set on an acre of land. They had been well fertilized and cultivated, were seven to eight feet tall and were healthy and vigorous with the exception that several limbs on prac-

tically every tree had been attacked by scab the season before. Some of these were so severely injured as to kill them back for several inches. However, the badly attacked trees were by no means confined to any one part of the block. They were visited about the first of July.

It was the original plan of the owner to spray the trees before the buds opened with a dormant spray of lime-sulphur and again with the same material diluted to summer strength, just before the flower buds opened, and a third time after the petals fell. The first application was made about the first of May, using a 33° Baumé, concentrate, diluted 1 part to 10 of water. At this time the leaf buds on one row of 8 trees were slightly in advance of the rest and were just beginning to open. The owner fearing he would injure them omitted the application of the strong spray upon this row of trees. However the remainder of the entire block received the dormant spray at this time, and all received the two later applications.

At the time the orchard was inspected, the leaves on the 32 trees to which all three applications of the spray were made were exceedingly healthy, although scab was not entirely controlled upon them. Those upon the 8 trees where the dormant spray was omitted showed a strikingly different condition. Fully 75 per cent were attacked by scab and a large proportion of these were quite severely affected. In fact only those of recent growth were free from the disease.

In closing it may be said that it is not our contention that the ascospores formed on the leaves of the previous year are not the source of a great proportion of, and usually all, of the early spring infection of apple scab. It is, however, maintained that, under certain conditions, and with certain varieties of apple trees, diseased twigs and water sprouts are an important factor in the propagation and spread of the disease at the beginning of the following year. Also it would seem from the observations here recorded that where limb infection exists the application of some strong fungicide immediately before the leaf buds open will greatly reduce the amount of spring infection from this source.

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PHYTOPATHOLOGICAL NOTES

Puccinia pruni-spinosa killing plum nursery stock. In the course of some nursery inspection near Fort Smith, Arkansas, the "plum rust" (*Puccinia pruni-spinosa*) was found killing nursery stock. The plum affected was reported to be Abundance. Several trees in the nursery row are badly affected, and a few of the trees had died on August 5.

J. LEE HEWITT

Rose Mildew. I very recently found a very interesting case of rose mildew on the low wild rose, *Rosa arkansana*. This species is apparently immune to the disease, at least here, but on some of the leaves there has been formed a gall, probably caused by gall flies, and these galls were badly infested with the oidium of rose mildew. The galls, about one-quarter to three-eighths of an inch in diameter, were completely covered with the white mass of the oidium, but it did not extend to the surface of the leaves in any degree.

I also found some very excellent specimens of the peach scab, *Cladosporium carpophilum*, on the leaves of some seedling peaches. The spots were small, circular, about 1 to 3 mm. in diameter, dark green to brown. The color is even, the margin entire. At first sight the spots look like small numerous apple scab infections. The spots are mostly on the upper surface perhaps, but are on both surfaces on the leaf.

J. LEE HEWITT

Personals. Dr. James T. Barrett, recently Associate in Botany at the University of Illinois, and Chief Assistant in Botany in the Illinois Experiment Station, has been appointed Plant Pathologist in the Citrus Experiment Station and Professor of Plant Pathology in the Graduate School of Tropical Agriculture at Riverside, California.

Personals. John Stevenson, recently a graduate student and assistant in the Department of Botany at the University of Minnesota, has been appointed assistant plant pathologist in the Sugar Planters' Experiment Station, Rio Piedras, Porto Rico.

Mark A. Carleton has recently resumed his duties as cerealist in the Bureau of Plant Industry, after a year and three months' leave of absence as director for the Pennsylvania Chestnut Tree Blight Commission.

Orlo A. Pratt, formerly assistant plant pathologist in the Idaho Agricultural College and Experiment Station, has been appointed scientific assistant in the office of cotton and truck disease, and sugar plant investigations of the Bureau of Plant Industry. His headquarters and address is Jerome, Idaho.

H. A. Edson of the Bureau of Plant Industry has transferred his headquarters and address from Madison, Wisconsin, to Washington, D. C.

Lewis E. Longely, recently floriculturist at the Washington State Experiment Station, has been appointed scientific assistant in the office of cotton and truck disease, and sugar plant investigations of the Bureau of Plant Industry, with headquarters at Madison, Wisconsin, where he will be engaged in breeding experiments with sugar beets.

C. W. Carpenter, sometime assistant bacteriologist in the Vermont Experiment Station, has been appointed scientific assistant in the office of cotton and truck disease and sugar plant investigations of the Bureau of Plant Industry. C. M. Woodworth, scientific assistant in the same office, has resigned in order to undertake graduate work at the University of Wisconsin.

NOTICE TO ALL MEMBERS OF THE AMERICAN PHYTO- PATHOLOGICAL SOCIETY

The annual meeting of the Society will be held in connection with that of the American Association for the Advancement of Science, at Atlanta, Georgia. during Convocation week, December 29, 1913 to January 2, 1914, the exact dates to be subject to later arrangement.

In accordance with a resolution adopted by the Society at its Cleveland meeting, the Secretary was instructed to call for titles and abstracts of about 200 words, of all papers to be presented at the coming Atlanta meeting. Abstracts should be in the Secretary's hands by Nov. 15 in order that they may be published and distributed to members before the meeting.

C. L. SHEAR,
Secretary

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PHYTOPATHOLOGY

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THE IMPORTANCE OF THE TARNISHED PLANT BUG IN THE DISSEMINATION OF FIRE BLIGHT IN NURSERY STOCK

V. B. STEWART

WITH PLATE XXIII

For the past five summers considerable attention has been given to the dissemination of fire blight bacteria or *Bacillus amylovorus* (Burr.) Trev. in nursery stock, by various insects, and the results of some observations made have been incorporated into a previous publication by the writer.¹ Therein it is stated: "It has been definitely proved that aphids (*Aphis pomi* De Geer) spread the disease and observations during the past two seasons indicate that several other sucking insects may disseminate the blight bacteria in the nursery. On July 1, 1912, the following species of sucking bugs were collected from apple nursery stock by Prof. C. R. Crosby of the Department of Entomology, Cornell University: *Reduviolus ferus* Linn., *Plagiognathus politus* Uhler, *Platymetopius acutus* Say., *Empoasca mali* Le Baron, *Typhlocyba rosae* Linn., *Campylomma verbasci* Meyers, and *Lygus pratensis* Linn." During the past summer, Mr. M. D. Leonard of the Department of Entomology, Cornell University, collected the following species which should be added to the list: *Orthotylus flavosparsus* Sahlb., *Chlamydatus associatus* (Uhl.) Reut., *Cosmopepla carnifex* Fab. and *Siphocoryne avenae* Fab.

Among these insects the tarnished plant bug (*Lygus pratensis* Linn.) has appeared to be the most important in transmitting the blight parasite to healthy trees, and usually it has been the most common insect observed on the stock susceptible to the disease. During the month of July the tarnished plant bugs are most abundant on the apples and as a rule the blight has become more prevalent in the apples with their appearance. This has been especially true for the past three seasons. As determined by the experiments subsequently discussed, these insects disseminate the blight in the following manner:

¹ Stewart, V. B. The fire blight disease in nursery stock. New York (Cornell) Agr. Exp. Sta. Bul. 329: 317-371. 1913.

Visiting blighted tissues the insects become smeared with the gummy exudate from the blight lesions and carry bacteria to the tender twigs. Here in sucking the sap the insects puncture the tissues, thus forming a means of entrance for the blight germs with the result that the twigs may soon become infected.

A number of seedling apples used for grafting purposes were planted in the month of April and from each of these several tender shoots developed which afforded excellent material for the following experiments:

EXPERIMENT I

On June 19, 1913, several tarnished plant bugs, obtained by sweeping wild mustard plants with a net, were smeared by means of a camel's hair brush with a seven-days-old agar culture of *Bacillus amylinus* and placed on the shoots of three different trees. By means of the camel's hair brush, the six shoots of two other trees were smeared with the agar culture of the causal organism and several tarnished plant bugs placed on the smeared shoots. The four shoots of two other seedlings were smeared with the agar culture but the bugs were excluded. Also the tarnished plant bugs were placed on the five shoots of two other trees which had not been smeared with the blight bacteria.

All trees were covered with wire screen cages, with an outside covering of white cheesecloth. The cages were about four inches in diameter and fourteen inches high. Care was taken not to injure the shoots when the cages were being placed over them.

On June 25 the cages were removed and about 70 per cent of the shoots were badly blighted on the trees where both the blight bacteria and the bugs were present.

All the shoots on the check trees remained healthy except that a slight injury, like that caused by the tarnished plant bugs, was apparent on the trees where the bugs were caged but the blight organism excluded. The shoots smeared with the agar culture failed to blight when the tarnished plant bugs were not present.

EXPERIMENT II

On June 27 some of the blighted shoots of the previous experiment showed the characteristic gummy exudation. Tarnished plant bugs, obtained again from sweeping wild mustard, were placed on the diseased shoots and the trees covered with the wire screen cages as before. Two blighted trees were covered in this manner. The bugs, ten in each cage, were allowed to run over the exuded shoots for a period of five hours. They were then transferred to the shoots of two healthy trees and covered with the cages.

At the same time three shoots of a healthy tree were smeared with a pure agar culture of the causal organism and several bugs caged over the trees for five hours, then transferred to another tree free from blight.

Ten bugs were enclosed in a cage over a tree with three tender shoots.

All the cages were removed on July 3, and a large percentage of the bugs were still alive. In one cage all of the shoots (three in number) were badly blighted where the bugs were transferred from the trees with the gummy exudation; in the other cage containing bugs from trees bearing the exuding lesions, two of the four shoots were diseased.

Two of the three shoots were affected where the bugs had been transferred from the trees smeared with the agar culture. The tarnished plant bugs taken directly from the wild mustard plants and placed on the check tree produced the characteristic injury of the tarnished plant bug but none of the shoots blighted.

From the experiments conducted it is evident that the tarnished plant bugs are able to transmit the causal organism of fire blight from exuding blight lesions to healthy shoots. Their importance in the actual dissemination of the blight bacteria is more strongly emphasized by conditions which existed during the past season.

On May 14, 1913, about thirty blighted two-years-old Kieffer pear trees were found in a large block of pears in the nursery row. The infections had occurred at the tips of the young tender shoots and in several trees the blight had involved a portion of the trunks. The diseased trees were confined to definite areas and from all appearances the blight had been spread by insects.

Judging from weather conditions the infections had occurred about two weeks earlier during a period of warm weather which was favorable both to the growth of the new shoots and also for the appearance of the numerous sucking bugs found on nursery stock. The infections at the time of discovery were all considerably advanced, but there had been no spread of the disease for some time because of the recent cold weather which had a tendency not only to check the activities of the sucking insects but also to retard the blight organism.

About May 1, the Kieffer pears, which are an early growing variety, were practically the only pear trees that had made any growth, and at this time Professor Crosby reported the presence of a large number of tarnished plant bugs feeding on the new, tender shoots. Evidently some of these bugs had visited a hold-over canker which was subsequently found on a tree in that vicinity. The bacteria in the hold-over canker had again become active with the ascent of sap in the spring, causing an exudation which furnished a source for new infections when visited by the bugs.

The other varieties of pears were not attacked because very little new

growth had been made at this time. Only two infections were found in the Clapp Favorite; the remainder were found in the Kieffer variety. The diseased trees were removed and all sources of infection eradicated. Although the bugs were present in abundance on these trees for some time to follow, practically no more blight occurred in the pear block for the remainder of the summer. It is believed that a severe blight epidemic was averted by this prompt eradication of sources of infection.

The conditions as discussed above emphasize the necessity of removing all blight infections as soon as they appear. Without the sources of infection, the presence of the various disseminating agents is not so important.

CORNELL UNIVERSITY
ITHACA, N. Y.

EXPLANATION OF PLATE XXIII

The bug is shown natural size and enlarged. From a photograph by Prof. M. V. Slingerland. The shoots on the blighted tree, at the right, were inoculated by bugs transferred from twigs exuding blight bacteria. The other tree, at the left, was infested with bugs collected from wild mustard. It did not blight. Trees nearly natural size.



PLATE XXIII THE TARNISHED PLANT BUG AND ITS WORK

BLACK PIT OF LEMON¹

CLAYTON O. SMITH

WITH PLATE XXIV

This blemish has been appearing occasionally for the past three years on the two chief commercial varieties of lemons, the Eureka and Lisbon, being somewhat more abundant on the latter. The trouble has gradually increased, and is now assuming some economic importance, occurring to a limited extent in all the lemon growing sections of southern California. It develops in the grove on tree-ripe lemons during the spring months, and does not reappear during the remainder of the year.

The spots or pits confine themselves entirely to the rind, are circular or oval in outline, 5 to 20 mm. in diameter, firm (not a soft rot), reddish-brown (isabellinus) to brown (castaneus²) or black. The tissue is depressed somewhat below the bottom of the normal oil glands into the white portion of the rind. In the center of the pit is usually to be found a thorn stab or other injury where the infection has taken place. The line between the healthy and diseased tissue is distinct and sharply defined. Professor Rolfs' illustration of the withertip fruit spot in his bulletin *Wither-Tip and Other Diseases of Citrus*, etc. would also serve as a good illustration of the black pit disease.³

These pits, when first observed, were at once associated with Professor Rolfs' illustration and cultures were made to isolate the supposed fungus, but these gave negative results. When the trouble again appeared, some of the affected tissue was inoculated into healthy lemons that were left on the tree. These inoculations gave a considerable number of typical infections which showed very conclusively that some active organism was present. Other cultures were now made in tubes of dilute prune juice and in petri dishes of nutrient agar. After a week's time thirteen tubes of prune juice showed no growth, while in three *Penicillium* had developed. In the agar dilution cultures, several suspicious white colonies appeared and were transferred to agar slant tubes. From these transfers artificial inoculations were made on lemons growing in the open. Successful results

¹ Paper No. 1, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

² Saccardo, P. A. *Chromotaxia seu nomenclator colorum*.

³ U. S. Dept. Agric., Bur. Pl. Ind., Bul. 52, plate 3, fig. 1.

appeared in about five days. The organism can readily be isolated from diseased tissue and has been repeatedly reisolated from artificially produced pits.

In these preliminary studies the diseased fruits were also kept in a moist chamber to favor the development of any organism that might be present and the following observations were made after the diseased lemons had remained for some time in a moist chamber. (1) A bacterial exudation often appeared at the points where the tissue had been pierced by some natural agent, possibly a thorn. (2) Sometimes pits were observed to enlarge slightly, and in one instance two coalesced. (3) Cuts made through the diseased tissue often showed an exudation at the vascular bundles of the diseased rind. An examination of this substance under a microscope showed it to consist of bacteria. (4) What appeared to be small pustules on the surface of the pit occurred. These gave every indication of the initial formation of accrevuli, but spores never developed. An examination of these and the tissue showed the presence of bacteria. (5) Clouded drops of liquid containing many bacteria often accumulated on the surface of the diseased pits produced by artificial puncture inoculations.

Artificial inoculations have been made (1) by puncturing fruit with a sterile needle and transferring the organism from a pure culture, (2) by using a hypodermic syringe, (3) by atomizing the fruit in moist chambers.

The first two methods have been employed both on fruit in moist chamber and that still attached to the tree and subject to normal climatic conditions. Successful inoculations have, almost without exception, resulted from puncture inoculation in three to ten days. Some successful ones were also secured from atomizing, but here only a very few pits developed, and then only on about one-half of the fruits sprayed. The following citrus fruits have been successfully inoculated by punctures: Eureka lemon, Valencia orange, navel orange, grape fruit and sour limes. These results are summarized in the following table.

Definite spots begin to develop in three to five days from inoculation. The beginning of the pit first shows in the tissue immediately surrounding the puncture as a slight darkening of the oil glands, soon followed by that of the intermediate tissue. The tissue beneath the surface of the pit becomes discolored with a distinct dark line between the diseased and healthy tissue. This diseased condition extends through the rind to the pulp. The spots after reaching a certain size, 5 to 20 mm., do not increase further, except in rare instances, but become depressed, smooth, firm, and of a brownish (castaneus) or black color. At the outer margin of the pits sometimes a reddish brown zone develops. The black pit of lemon somewhat closely resembles spots found in nature on citrus fruits other than lemon, but its identity with these blemishes has not yet been demonstrated.

Artificial inoculation on lemons

HOW INOCULATED	LEMONS	DATE	ENVIRONMENT	RESULT	DATE
Diseased tissue	4 tree ripe	3/30/11	On tree	Positive	4/11/11
	3 tree ripe	4/11/12	On tree	Positive	4/23/12
Puncture culture	2 tree ripe	5/26/12	On tree	Positive	5/31/12
	3 green	5/31/12	On tree	Positive	6/10/12
Hypodermic	3 tree ripe	6/1/12	On tree	Positive	6/10/12
	1 tree ripe	6/3/12	On tree	Positive	6/10/12
Check puncture	3 green	6/3/12	On tree	Positive	6/10/12
	2 tree ripe	6/5/12	On tree	Negative	6/13/12
Puncture culture	3 tree ripe	9/28/12	On tree	Positive	10/8/12
Hypodermic	3 tree ripe	6/6/12	Moist chamber	Positive	6/25/12
Atomizing	14 tree ripe	6/6/12	Moist chamber	8 Positive	6/13/12
Puncture culture	5 tree ripe	6/6/12	Moist chamber	Positive	6/17/12
	3 tree ripe	9/28/12	Moist chamber	Positive	10/28/12
	3 green	10/24/12	Moist chamber	Positive	10/30/12
	3 green	10/31/12	Moist chamber	Positive	11/10/12
	3 tree ripe	12/6/12	Moist chamber	Positive	1/10/13
	4 tree ripe	12/11/12	Moist chamber	Positive	1/11/13

Artificial inoculations on other citrous fruits

HOW INOCULATED	FRUIT	DATE	ENVIRONMENT	RESULT	DATE
Puncture culture	3 yellow limes	6/24/12	Moist chamber	Positive	6/27/12
	3 yellow limes	6/26/12	Moist chamber	Positive	7/1/12
Hypodermic	3 yellow limes	6/26/12	Moist chamber	Positive	7/1/12
Atomizing	7 tree ripe limes	6/26/12	Moist chamber	Doubtful	7/17/12
Puncture culture	1 grape fruit	7/1/12	On tree	Positive	7/18/12
Hypodermic	3 grape fruit	7/1/12	On tree	Positive	7/18/12
Puncture culture	1 Valencia orange	6/1/12	On tree	Positive	6/10/12
	3 navel oranges	11/6/12	Moist chamber	Positive	11/12/12
Atomized	3 navel oranges	11/6/12	Moist chamber	Negative	12/6/12
Puncture culture	4 Valencia oranges	11/11/12	Moist chamber	Positive	11/20/12

The black pit organism in young agar cultures is actively motile by a single polar flagellum (Pitfield's stain). It measures 1 micron or less in shorter diameter and is two or three times as long as broad. It is usually single, may be found in pairs, but has only very rarely been observed to occur in chains. No spores or capsules have been demonstrated.

On slant tubes of standard nutrient agar the growth is pearl gray, thin and spreading. In standard nutrient agar dilution cultures the surface colonies appear in two to three days at 26 to 29°C. They are grayish-white, circular, 2 to 2.5 mm. in diameter, with rather indistinct entire margins, the whole structure of the colony being composed of very fine granules as seen with a low power of a compound microscope. The deeper colonies appear bi-convex in shape.

On standard 10 per cent gelatin a stratiform type of liquefaction occurs rather slowly, and a white precipitate is deposited on the unliquefied surface before liquefaction is completed. Bouillon is clouded rather densely, producing a ring-like formation on the sides of tube at the surface of the media. In some of the sugar bouillons a definite pellicle is formed at the surface. The organism is aerobic, no gas forming during thirty days in all the sugars tried: dextrose, lactose, galactose, saccharose, maltose, glycerine and mannite.

On potato cylinders the growth is at first white, but changes to a pearl-gray color; a grayish staining of the cylinders also occurred, while check tubes retained their white color.

Indol was shown to be formed in ten days in Dunham solution, incubated at 26 to 29°C.

On sterilized orange and lemon rind there is a characteristic growth that differs from the pearl-gray color that is produced in other media. At first this appears to be straw color (stramineous),⁴ but in two weeks has changed to a putty color, and in one month has become dark fawn.⁵ The rind has also darkened, becoming at the end of thirty days a chestnut brown. In artificial puncture inoculations on lemons in a moist chamber piled-up putty colored⁶ drops of bacterial growth often accumulate at the surface where the original punctures were made. On 3 per cent glucose lemon agar (a decoction of lemon rind), and on this same agar diluted with an equal part of standard nutrient agar, the same colored bacterial growth is formed as on lemon and orange rind. Transfers of this colored growth back to standard nutrient agar develop the pearl-gray color again.

In milk and litmus milk the tubes at first show no change, but gradually become intensely alkaline and clear without the separation of the casein.

***Bacterium citriputeale* nov. sp.**

*Latin diagnosis.*⁷ Baculis cylindricis apicibus rotundatis, solitariis aut geminatis, 2-4 x 0.5-1 μ , mobilibus, aerobiis, neque capsulas neque sporas

⁴ Saccardo. Loc. cit.

⁵ Danthenay, Henri. Repertoire de couleurs, pp. 311, 307.

⁶ Danthenay. Loc. cit., p. 311.

⁷ Translated through the kindness of Prof. W. A. Setchell.

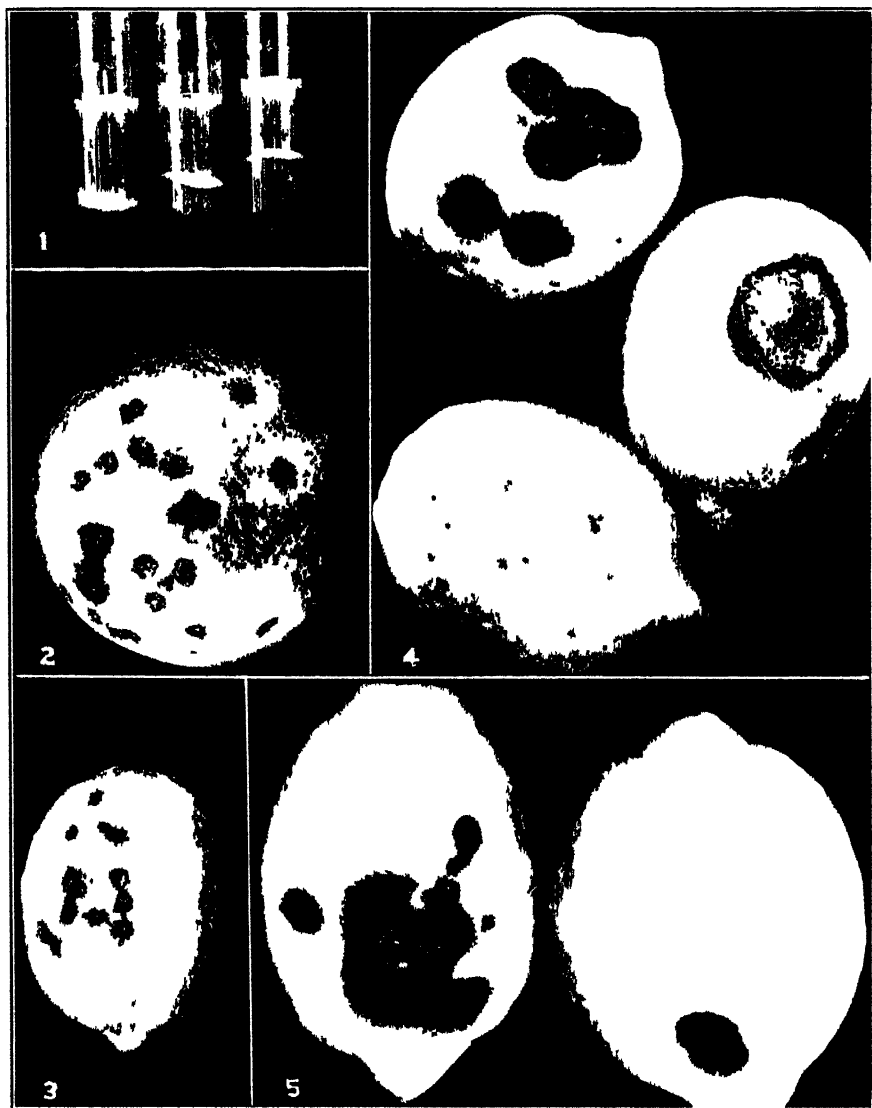


PLATE XXIV BLACK PIT OF LEMON

FIG 1 Gelatin tubes showing partial liquefaction and white deposit on un-liquefied portion

FIG 2. Navel orange inoculated with pure culture by puncture, and kept in a moist chamber for six days

FIG 3. Puncture inoculations with steel needle, of lemon on tree ten days time

FIG 4 Two tree-ripe lemons inoculated on tree by hypodermic injection, seven days development, one lemon as check

FIG 5 Black pit as found on lemon trees, natural infection

formantibus, in medio saccharino aerem non producentibus, putea depressa, discolorata, 5-20 mm. diam. in cortice fructus Citri Limoni in ditione Californiensi incolentibus. Coloniis superficialibus in agar-agar margaritaceo-griseis, orbicularibus, 2-5 mm. diam. post dies 3 apud 26°-29°C. incubatis, levibus, nitentibus, marginibus integris; in cylindricis Solani tuberosi cultis, margaritaceo-griseis cum evidenter discolore et cum colore griseo augmento; in lacte sterili cultis primo non mutantis sed aetate proVectiore alkalinis lucidisque sine "casein" segregatione: in solutionem "Dunham" dictam in dies 10 "indol" formantibus; in gelatinam cultis liquationem stratiformen inducentibus; in cortice fructus Citri Limoni inoculatis, putea profunda typica 3-15 mm. diam in dies 3-10 facientibus.

SOUTHERN CALIFORNIA PLANT DISEASE LABORATORY

UNIVERSITY OF CALIFORNIA

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PRODUCTION OF SECONDARY SPORIDIA BY GYMNOSPORANGIUM¹

C. H. CRABILL

WITH ONE FIGURE IN THE TEXT

In the spring of 1913, while conducting investigations on the cedar rust fungus, the writer observed the production of secondary spores by the germinating sporidia of *Gymnosporangium juniperi-virginianae* Schw. These spores have been designated "secondary" sporidia to distinguish them from the primary sporidia from which they originate.² The following observations upon the development of these spores have been made.

On March 28, 1913, some "cedar apples" were gathered and placed in a moist chamber. The following day highly gelatinous tentacles had been put forth and teleutospores in abundance were secured. Some of these teleutospores were placed in hanging drops of water and examined from

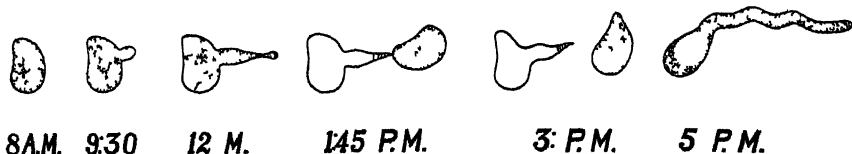


FIG. 1. Successive stages in the production of a secondary sporidium from a primary sporidium.

time to time. They germinated in the ordinary way with the production of four sporidia on the promycelium from each teleutospore cell.

On March 30 it was noticed that some of these sporidia had germinated and instead of producing vegetative hyphae had each produced on a short sterigma, a secondary spore identical in shape, color, and markings with the primary spore but slightly smaller in size.

This aroused suspicion and more hanging drops were prepared. The production of secondary sporidia was observed in all cases. On April 10 the following note and the accompanying drawings were made.

¹ Paper No. 27 from the laboratory of Plant Pathology, Virginia Agricultural Experiment Station. The writer is indebted to Dr. H. S. Reed for criticising this paper.

² Kunkel, Otto The production of a promycelium by the aecidiospores of *Caeoma nitens* Burrill. Bul. Torrey Bot. Club 40: 361-366. fig 1 1913. Casual mention is here made of the production of secondary sporidia by *Caeoma nitens*

Some Van Tieghem cells were prepared with distilled water and inoculated with sporidia from cedar apples made gelatinous in a moist chamber. One of these showing a good field was clamped under the microscope and watched all day. Each sporidium germinated as follows: A budlike process was put forth at some point on the sporidium wall. There seemed to be no definite place to put forth this bud. The bud elongated and the protoplasmic contents of the sporidium extended into it. After growing about 10-25 microns long the bud became pointed and tipped with a little globular body which swelled rapidly and became a secondary sporidium into which the contents of the primary sporidium flowed, leaving the latter empty and hyaline. The secondary sporidium thus produced remained attached to the old sporidium in one case only about an hour. Usually they stayed attached much longer. The process on which the secondary sporidium is borne is virtually a sterigma identical in appearance with those on which the sporidia of the promycelium are borne. The secondary sporidia then germinated producing vegetative hyphae into which the protoplasm flowed. Beyond this no growth took place and the spore and mycelium finally collapsed.

Observations were continued throughout the period of spore production by the cedar apples and almost invariably the production of secondary sporidia took place abundantly.

In two instances, however, April 16 and 19, a large percentage of the sporidia set for germination in hanging drops produced vegetative hyphae directly, without the intermediary production of secondary sporidia. The sporidia used for these two germination tests were secured from cedar apples which were drying after having become gelatinous in a moist chamber.

Much difficulty was encountered in preparing permanent slides properly stained with which to record the process of secondary sporidia production. The following method finally gave good results.

A quantity of teleutospores was placed in water in early morning and a mount was made every half hour during the day.

1. A few loops of the material were transferred to a cover glass and allowed to dry in the air.

2. As soon as dry it was covered with cold carbol-fuchsin for three to five minutes. The secret here is to get the stain on as soon as the material is dry.

3. The excess of stain was removed by carefully dipping the cover glass into water.

4. The cover glass and material were then allowed to dry in air.

5. As soon as dry the preparation was mounted in balsam on a slide.

By this method a good series of slides was obtained showing all stages in the production of secondary sporidia.

The production of secondary sporidia seems to be the rule, and direct germination or the production of a germ tube directly from the primary sporidium the exception. The question naturally arose, what are the conditions which determine whether the germination of primary sporidia is to be direct or indirect? As we noticed before, when teleutospores are placed in hanging drop they produce sporidia which in turn immediately produce secondary sporidia. This has been repeatedly observed. Again, if sporidia are produced on the cedar apple, allowed to dry, and then placed in hanging drop, a large percent of them produce germ tubes directly, while only a small number produce secondary sporidia. This was twice observed, April 16 and 19.

Later in the season when the warm rains began, it was noticed that when several consecutive days of rain occurred and the cedar apples were kept moist for a long time the teleutospores germinated with the production of sporidia which in turn produced secondary sporidia abundantly in situ. When, on the other hand, a shower was followed by sunshine or wind and the cedar apples dried up rapidly, primary sporidia were produced in abundance and shed as soon as dry. If these dry primary sporidia were collected and placed in water they germinated, some producing germ tubes directly and some producing secondary sporidia.

The indications are that, when kept continually moist from the time of production, the primary sporidia will produce secondary sporidia and that, when the primary sporidium becomes dry immediately following its production, and subsequently wet, it may germinate either directly or indirectly. The extent of the dryness may be the determining factor. Further investigations will be made.

Are the secondary sporidia able to survive a drying or resting period before germination? Are they produced when conditions for infection are not good and are they able to tide the fungus over until conditions are good? These questions remain unanswered.

It is barely possible that in case a primary sporidium germinates in an uncongenial environment, on the ground, for example, or on foliage which it cannot infect, that a secondary sporidium may be produced, which when dry might be transferred by the wind to an apple leaf and there in the presence of moisture cause infection. This, however, is mere speculation and no doubt will justify further investigation.

The production of secondary sporidia has also been observed by the writer in *Gymnosporangium clavipes*. This phenomenon may be common to other species of *Gymnosporangium*.

BLACKSBURG, VIRGINIA

A PRELIMINARY NOTE ON POLYPORUS DRYADEUS AS A ROOT PARASITE ON THE OAK¹

W. H. LONG

Bulliard in 1789 figured and described under the name of *Boletus pseudo-igniarius* a fungus which most European mycologists believe is the plant now called *Polyporus dryadeus*. In 1796 Persoon described it under the name of *Boletus dryadeus*, while Fries in 1821 first named it *Polyporus dryadeus*. Since then repeated references to this fungus have been found in European mycological literature, but nothing was written concerning the rot produced by it till Robert Hartig in 1878 described a heart rot of oak which he attributed to *Polyporus dryadeus*. A careful study of Hartig's figures and of his description of the sporophore, which he found associated with the heart-rot so accurately described by him, is sufficient to convince anyone who is familiar with the true *P. dryadeus* that Hartig's fungus was not *Polyporus dryadeus*.

The fungus with its associated rot as described by Hartig is undoubtedly identical with the heart-rotting fungus known in America as *Polyporus dryophilus* and found by Hedgecock associated with a whitish piped rot in oaks. *P. dryophilus* has one character that is unique and not possessed by any other polypore known to the writer, viz., its sporophore has a hard granular sandstone-like core, exactly as described by Hartig in his article on *P. dryadeus*. This hard core extends back some distance into the tree in oaks. It is usually irregularly cylindrical while in the tree, but on its emergence from the tree it swells into a tuberous or spheroidal mass and finally occupies the central and rear portion of the fully matured sporophore. This core usually has white mycelial strands ramifying through it. The sporophore of *Polyporus dryophilus* therefore has normally three distinct kinds of structures: (1) the hard granular core; (2) the fibrous layer which surrounds this core except at the rear; (3) the layer of pores or tubes on its lower side. Specimens are often found, however, especially in the western part of the United States in which this fibrous layer is entirely absent between the tubes and the core.

The sporophore of *Polyporus dryadeus* never has this granular core; its context is nearly homogeneous and of a corky-fibrous structure. Another difference between these two species is the location of the sporophores on

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the host tree. In *P. dryadeus* they are attached to the exposed roots or to the trunk of the oak at or very close to the ground, while in *P. dryophilus*, the sporophores are usually found higher on the bole of the tree.

Polyporus dryophilus is known in Europe under at least three different names, viz., *P. fulvus* Fries, *P. friesii* Bresadola, and *P. vulpinus* Fries.

The last is the name given to the form of *P. dryophilus* found on species of *Populus*. Authentic specimens of *P. vulpinus* from Finland and Sweden were seen by the writer in the New York Botanical Gardens. The writer has also seen specimens of this fungus on species of *Populus* from three different localities in the United States, viz., from Maine (in the New York Botanical Gardens), from New Hampshire (in the Herbarium of Harvard University), and from Colorado (in the Laboratory of Forest Pathology at Washington, D. C.). This fungus on *Populus* agrees in all essential characters with the form of *P. dryophilus* found on oak. The hard granular core is always present but is formed between the sapwood and the bark since the fungus is able to rot the sapwood as well as the heart wood of this host.

Through the kindness of von Tubeuf, the writer obtained a European specimen of Hartig's so-called rot of *P. dryadeus* in oak. It is undoubtedly the rot produced by *P. dryophilus*. The writer has repeatedly found the sporophores of the true *P. dryadeus* associated with a white sap-rot of the roots of oaks under such circumstances that there could be no doubt that *P. dryadeus* was the cause of this root-rot.

The roots and the stools of twenty oak trees attacked by this fungus were examined and the various stages of the rot studied. The disease was found in the forests of Arkansas, Texas, Oklahoma, Maryland, and Virginia.

The first evidence of the disease is a reddish brown discoloration of the inner bark and cambium. As the rot progresses, watery brownish areas appear on the surface of the sapwood and in its outer layers. This discoloration gradually spreads until the root is affected to its center. In the final stage of the rot, the color becomes white or creamy white. In all the uprooted trees examined, the disease began in the lower portion of the roots and spread upward toward the stool of the tree. The rotted roots become brittle and are therefore easily broken and the tree uprooted in a windstorm.

The rot in all the trees examined did not extend any distance into the heartwood of the trunk proper above the collar of the tree, even when the large roots were rotted throughout.

The writer found *Polyporus dryadeus* attacking the roots of *Quercus texana*, *Q. nigra*, *Q. alba*, *Q. velutina*, *Q. minor*, *Q. rubra*, and *Q. prinus*. No rhizomorphs of any kind were found associated with this rot, either beneath

the bark, or on the surface of the diseased roots, or ramifying in the adjacent soil.

Authentic specimens of *Polyporus dryadeus* from America, England, France, Germany, and Austria were examined by the writer and a careful comparison with the material used as the basis of this article showed that the American fungus under discussion is undoubtedly identical with the European plant known as *P. dryadeus*.

Polyporus dryadeus is therefore a root parasite on the oak producing a white sap and heart-rot in the roots.

In the majority of cases only old trees or trees much suppressed and growing under unfavorable conditions were found attacked by this fungus. The disease does not seem to spread readily to adjacent trees.

The writer in a subsequent article will give a more detailed discussion of this fungus.

U. S. DEPARTMENT OF AGRICULTURE

WASHINGTON, D. C.

CONTROL OF APPLE BLACK-ROT

FREDERICK A. WOLF

The fungus, *Sphaeropsis malorum* Peck, is quite widely known throughout the United States yet it is generally considered as of minor importance as a rot of apples. It more frequently manifests itself as a canker on the trunk and limbs, or as a leaf spot, being sometimes so severe as to result in the premature defoliation of the trees. Attention has recently been directed to it, however, because of its destructiveness as a fruit rot in certain commercial apple orchards in Northern Alabama. Since it is not apparent from available literature that there is any exact experimental data relative to its control, and since more or less serious annual losses are incurred from its ravages, some work upon its control, has been initiated. It is the present purpose merely to give in a preliminary way some general statements that seem to be warranted from the results already obtained.

These experiments are being conducted near Fort Payne, Alabama, in an orchard of eight thousand trees, consisting in the main of Black Ben Davis, Champion, Delicious, and Early Harvest, of which the first appears to be the most susceptible to black rot. These trees are vigorous, well pruned, remarkably free from cankers, and the ground is in an excellent state of cultivation. Very considerable losses were occasioned in this orchard, in 1912, from bitter rot. This disease together with black rot seems to over-winter, so far as present observations go, on mummified and fallen fruits. A power sprayer, in which a pressure of two hundred pounds was maintained, has been used throughout the operations.

During last season commercial lime sulphur alone was used as a fungicide. Suffice it to say that it proved entirely ineffective against either blackrot or bitter rot, irrespective of the time of application and the number of applications, hence its use cannot be recommended, at least under southern conditions. During the present season Bordeaux mixture, 4-4-50, has been used. The first application was made about the middle of July, upon the first appearance of the disease as a small dark spot in the bud end of some of the apples. A second application was made two weeks later to insure complete protection against subsequent infections. Most satisfactory results were obtained from this work, in view of the fact that the number of diseased fruits, upon the Champions, was less than one per cent. Only 85 per cent to 90 per cent control was obtained with Black Ben Davis. This loss could, no doubt, have been lessened had the first

application been made ten days earlier. The losses from bitter rot were inappreciable although this disease entailed severe losses in some sections of the state.

These investigations have definitely shown that the black rot of apples can be controlled in Alabama by the timely application of Bordeaux mixture. Waite controlled the disease in 1901, and Scott in 1905, in connection with bitter rot experiments¹ in Virginia. Two applications only of 3-3-50 Bordeaux mixture were required. In view of the fact that apples adjacent to old mummies are generally the first to show the disease, there is no doubt that they are the primary source of infection. Further, the affected leaves do not seem to be responsible for the spread of the disease to the fruits, since mature pycnidia seem to occur only on old fallen leaves. On this account sanitary measures relative to the collection and destruction of all diseased fruits, both fallen specimens and mummies, cannot be too strongly recommended. If, in addition, the leaves are plowed under during winter or early spring, one may reasonably expect very effective black rot control from two timely applications of Bordeaux mixture.

ALABAMA POLYTECHNIC INSTITUTE

AUBURN, ALABAMA

¹ Scott, W. M., and Rohrer, J. B., Apple leaf spot caused by *Sphaeria malorum*. U. S. Dept. Agr., B. P. I. Bul. 121: 17-54. 1908.

PHYSALOSPORA CYDONIAE

LEX R. HEDSLER

WITH PLATE XXV AND TWO FIGURES IN THE TEXT

In connection with studies on the New York apple tree canker several interesting problems have presented themselves. Among these may be mentioned: parasitism of *Sphaeropsis malorum* Berk.,¹ the identity of the organism, the comparison of different strains or races, the relationship of *Sphaeropsis* to *Diplodia*, and the question of the perfect stage. The object of this paper is to discuss the ascomycetous form of the fungus and to present the results of the investigation.

Fückel² in his description of *Othia pyri* states that the pycnidia are very similar to those of *Diplodia pseudo-diplodia* and *Diplodia malorum*. Delacroix³ is of the opinion that the former species is the same as *Sphaeropsis malorum* Pk. and unites the two under the name *Sphaeropsis pseudo-diplodia* (Fückel) G. Del. The justification of this move will not be discussed here. It is desired merely to call attention to Fückel's suggestion that *Othia pyri* may be the perfect stage of the pycnidial form in question. Shear⁴ cultured ascospores of *Melanops quercuum* [*Botryosphaeria fuliginosa* (M. & N.) E. & E.] and obtained pycnidia bearing spores of the *Macrophoma* or *Dothiorella* type which later turned brown and some of which became once-septate, corresponding to *Sphaeropsis viticola* Pass. and *S. peckiana* Thüm. He states further that these spores also agree morphologically with *S. malorum* Pk. and *D. pseudo-diplodia*. In a few cases he found another form of pycnospor in the same pycnidium with the *Sphaeropsis* spores; these were small, hyaline, cylindrical, 2 to 3 by 1 μ , and were observed in the hosts and not in the cultures. Arnaud⁵ observed an ascomycete associated with *S. pseudo-diplodia* (Fückel) G. Del. which he named *Physalospora cydoniae* Arnaud. His opinion, based on

¹ The synonymy is given by Edgerton, C. W., Two little known Myxosporiums. *Ann. Myc.* 6: 48-53. 1908.

² Fückel, *Symbolae Mycologicae* 1869: 307.

³ Delacroix, G., Sur l'identité réelle *Sphaeropsis malorum* Pk. *Bul. Soc. Myc. France* 19: 350-352. 1903.

⁴ Shear, C. L., Life history of *Melanops quercuum* (Schw.) Rehm. forma *vitis* Sacc. *Science n. s.* 31: 748. 1910.

⁵ Arnaud, G., Notes phytopathologiques. *Ann. L'Ecole Nat. Agr. Montpellier* 12: 9. 1912.

tirely on association of the two organisms, is that the latter is the perfect stage of the former. He makes no mention of pure culture work with which to verify his statements.

The writer has made repeated attempts to find the ascogenous form of *Sphaeropsis malorum* Berk. but had been unsuccessful until a few months ago. Affected leaves which had over-wintered on the ground of badly infested orchards have been examined, but these showed only the pycnidial form of the fungus. The older portions of the cankered spots also have been examined but these likewise failed to reveal the desired stage. Again affected leaves, twigs (some exposed and some others in jars,) and pure cultures from pycnosporos on various solid media (potato agar, oat agar, etc.), have been over-wintered with the hope that the perithecia might be developed. So far, however, such fruit bodies have never appeared.

In February, 1913, diseased apple twigs were received at the Department of Plant Pathology at Cornell University from the Stark Brothers Nurseries and Orchards Company, Louisiana, Missouri. It has since been learned that the specimens originally came from Croton-on-Hudson, New York. Free-hand sections and crushed mounts, in the majority of cases, showed only the pycnidial stage of *Sphaeropsis malorum* Berk. Occasionally, however, an immature ascomycete was observed. The twigs were placed in a moist chamber and, after a few days, mature asci were developed. Small bits of bark were imbedded in paraffin, and were subsequently sectioned and stained. Fortunately a very few perithecia were present on the prepared slides. Further search on one of these twigs revealed a few perithecia which, while standing entirely separate from one another, were more or less grouped in local regions on the bark. The ascospores were isolated and cultured at once.

Two methods of isolation were used. In the one case, single perithecia were removed, under the hand lens, with a flamed scalpel and promptly placed in a petri dish in a drop of sterile water. They were subsequently crushed and the plate poured with warm agar. A gentle shaking of the dish was sufficient to scatter the spores and asci. In some cases single ascospores, in others single asci bearing mature spores, were marked by aid of the low power of the microscope. Germinations followed in a few hours. Single spores or asci were then transferred to sterile tubes or flasks of agar and allowed to grow. The second method followed in isolating was by a modification of the process described by Barber.⁶ Perithecia were crushed in a drop of sterile water on a flamed slide and the mount placed under the low power of the microscope. A small glass rod, about fifteen or twenty cm. in length and with a bore of about 3 mm. was drawn to a cap-

⁶ Barber, Marshall, A., On heredity in certain microorganisms. Kansas Sci. Bul. 4: 3-48. pls. 1-4. 1907.

illary tip at one end; to the opposite end was fitted a piece of rubber tubing, about 40 or 45 cm. in length. The free end of the latter was placed in the mouth while the former was manipulated by the hand. By careful handling of the apparatus it was possible to pick out single ascospores. These were then planted in a drop of sterile water in a petri dish and the plate poured as in the first method of isolation. Further procedure was as in the first method.

On March 6, 1913, six plantings of ascospores in as many plates of +10 nutrient agar⁷ were made. On the same date several cultures of pycnospores from the same twig were also made using the same kind of media. The ascospore cultures grew slowly the hyphae remaining grayish in color. After sixty days the mycelium had covered only about two-thirds of the surface of the dish, with no evidence of fruiting (pl. XXV, fig. 8). The mycelium in the cultures from pycnospores grew rapidly, soon turning dark brown in color. Pycnidia bearing mature spores appeared after a period of about one week (pl. XXV, fig. 8). On March 10, 1913, bits of mycelium from the edge of the ascospore cultures were transferred to Erlenmeyer flasks containing oat agar. At first the color of the growth was grayish, as on the nutrient agar, but soon it became dark brown. On April 19, pycnidia were observed; they proved to be similar to those obtained in culture from pycnospores. The original ascospores cultures on nutrient agar were allowed to grow until they had dried out but no fruit bodies developed. Subsequent transfers were made from the ascospores cultures on nutrient agar under the following dates with results as indicated: April 15, to oat agar,⁸ mature pycnidia after eight days; April 28, to oat agar, pycnidia after ten days; April 28, to potato agar,⁹ pycnidia after eighteen days or less.

Isolations of ascospores were made again on April 16, 1913, using potato agar instead of nutrient agar; after twelve days mature pycnidia were found. Subcultures to oat agar developed pycnidia after a few days. Again, isolations of ascospores on April 17 and April 23 in potato agar, developed pycnidia within eleven days.

It should be noted that pycnospores and ascospores have very different types of growth on nutrient agar. To verify these results cultures were made as follows: (1) Ascospores isolated on March 6, 1913, gave only scant growth on nutrient agar; (2) transfers from (1) to oat agar on March

⁷ This medium was made according to the directions given in Frost, W.D. A Laboratory Guide in Elementary Bacteriology. 3rd Ed.: 16. 1907.

⁸ Oat agar made according to G. P. Clinton. Report of Botanist. Conn. Agr. Exp. Sta. Rept. 1909-1910 : 760-761. 1911.

⁹ Formula for potato agar: Wash and pare one medium sized potato and cook in double boiler for an hour. Filter and to filtrate add five grams of glucose, thirty grams of agar and make up to 1000 cc. with distilled water. Cook thoroughly over free flame, tube and sterilize.

10 showed fruiting in a few days; (3) transfers from (2) on April 15 and April 28 back to nutrient agar, gave again only a scant growth as in (1); and (4) transfers from (3) back to oat agar gave pycnidia in a few days.

In any such culture work contaminations are likely to bring about misleading results. It appears, however, that if in the original transfers of ascospores to nutrient agar pycnosporos had also been carried, the resulting culture would have shown semblance to that obtained by planting pycnosporos. In any case the growth from subsequent transfers make it very apparent that this possibility was eliminated.

During the past summer several inoculations have been made with cultures from the ascospores of the ascomycetous fungus. The apple, pear, quince, crab apple, and other plants were inoculated, in each case wounds being made to serve as infection courts. Three varieties of apples, namely Twenty Ounce, Baldwin, and Chenango Strawberry, were inoculated between May 20 and July 16, 1913. Eleven sets of experiments involving about seventy incisions were made, all of which gave positive infections, the checks remaining healthy (pl. XXV, figs. 2 and 3). On Duchess pear limbs only one set of inoculations, involving nine incisions, was made, but cankers were produced in every case, some of them attaining greater size than those produced on apple (pl. XXV, figs. 4, 5, and 6). The results on quince were unsatisfactory since but one infection was obtained out of five inoculations. On crab-apple twigs three incisions gave positive results, while all other attempts to infect failed on the several plants inoculated.

In June, 1913, an ascomycete on *Hamamelis virginia* was found. It so closely resembled morphologically the ascomycete on apple twigs that cultures were promptly made. Isolations on June 2, in potato agar, with sub-cultures on oat agar, gave pycnidia after fifteen days; they were morphologically similar to those of *Sphaeropsis malorum* Berk. On June 20 a second isolation gave pycnosporos after about ten days. About twenty-five different inoculations were made on all the plants mentioned above but no infections occurred. It is difficult to explain the failure of these inoculations. However, it is possible that there are biological races in the ascomycetous stage.

The perithecia are usually scattered, standing separate from one another. Sometimes, however, two to four fruit bodies are aggregated together, but no stroma has ever been observed. They are buried in the cortical tissues, protruding at maturity by a short, papillate ostiole. Their form is globose to sub-globose, measuring in the vertical diameter from 180 to 324 by 300 to 400 μ in the horizontal diameter, averaging about 225 to 325 μ (fig. 1).

The asci are abundant; they are usually clavate, though sometimes

tending to be cylindrical measuring 21 to 52 by 130 to 180 μ . The tip of the ascus is thickened, however a complete canal from the inner wall to the outside has not been observed only a suggestion of such has been seen even after the perithecia had been kept in a moist chamber for several hours (fig. 2). Examinations made at short intervals show that there is probably a gelatinization of the ascus and that the spores escape subsequent to this process. At the apex of a perithecium which has been subjected to moist chamber conditions may be found a whitish, gelatinous mass which is only the ascospores imbedded in a gelatinous substance. If free-hand sections are made, the basal portion of such a fruit body shows a gelatinous mass in which are buried a few ascospores and what appear to be the remains of the old ascus.

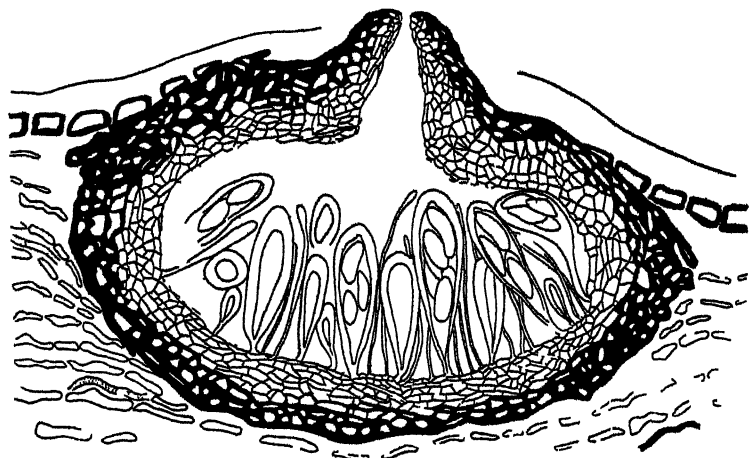


FIG. 1. Perithecium of *Physalospora cydoniae*. (Unpublished drawing.)

The ascospores are ellipsoidal or often they are inequilateral (fig. 2). They are hyaline to greenish-yellow, measuring from 10.8 to 15.2 by 23.4 to 34.2 μ averaging 11.5 by 28 μ . In the dry condition the material shows spores with a very thin gelatinous sheath, but after being under a saturated atmosphere for a few hours, the sheath becomes very broad and evident. The arrangement of the spores in the ascus tends to be more or less biserial (fig. 2). Germination has been easily obtained in water and in nutrient, potato and oat agars. Paraphyses are distinct and are occasionally branched near the tip. Not infrequently the apex shows a tendency to be clavate (fig. 2).

The characters just described seem to relate the fungus to the genus *Physalospora*. The presence of the gelatinous sheath about the spores suggests the family *Massariaceae*. However, this character is not pro-

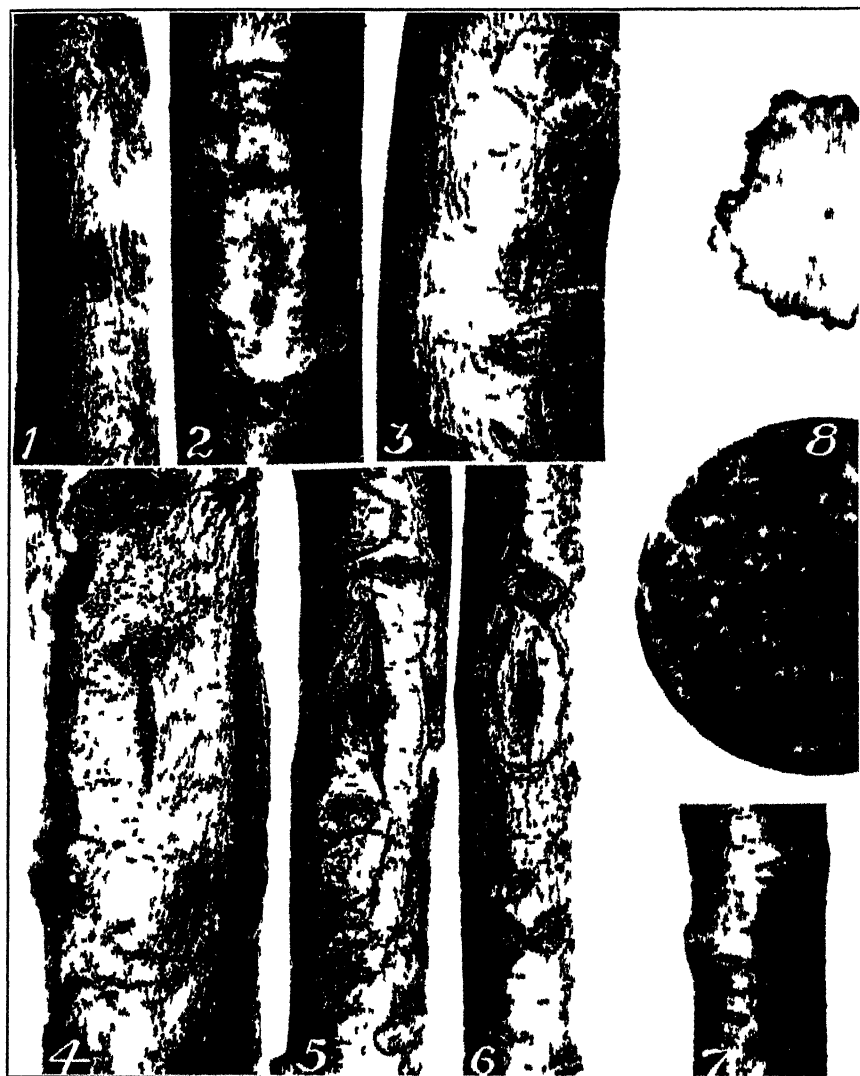


PLATE XXV. *Physaloscyta cydoniae*. INOCULATIONS AND CULTURE

- FIG. 1 Apple limb three months after inoculation with the *Physaloscyta cydoniae* from H. 10
 FIG. 2 Apple limb two months after inoculation with ascospores from apple
 FIG. 3 Check
 FIG. 4 Pear limb three months after inoculation with ascospores from apple
 Slightly enlarged to show pycnidia
 FIGS. 5 and 6 Same except that pycnidia have not appeared
 FIG. 7 Check on pear limb
 FIG. 8 Showing the stunted growth above of mycelium from ascospores on H. 10
 agar and growth below from pycnosporium on lime lime of medium

nounced in the dry condition and is not regarded as sufficient to warrant classification in this family. According to Winter¹⁰ in certain species of *Physalospora*, e.g., *P. festucae* (Lib.) Sacc. and *P. fallaciosa* Sacc., a thin gelatinous sheath is present about the ascospores, so that the species we have under consideration is not exceptional in this respect.

Ellis and Everhart¹¹ in their discussion of *Botryosphaeria fuliginosa* (M. & N.) E. & E. state that forms of the species lacking a stroma have been removed to the genus *Physalospora*. Until a more satisfactory system of classification is at hand, there seems to be no serious objection to the generic name which the writer has selected.

The problem of selecting a specific name is somewhat perplexing. The organism with which the writer is dealing strongly resembles *P. cydoniae* Arnaud but we have not seen his type material and there remains the question of whether his fungus has not been previously described. In this connection a few species which suggest this possibility may be noted: *P. entaxia* E. & E. *P. festucae* (Lib.) Sacc. and *P. nigropunctata* Romell, the last on limbs of *Pyrus malus* according to Saccardo.¹² Until further data are at hand the writer is inclined to accept tentatively the name *Physalospora cydoniae* Arnaud. With regard to *Melanops quercuum* (Schw.) Rehm forma *vitis* Sacc. discussed by Shear, it may be said that this organism clearly belongs to a stroma-forming group of Sphaeriales, and would appear to be a different form than *Physalospora cydoniae* Arnaud. It has been mentioned elsewhere in this paper that Shear found another form of pycnosporer intermingled with the Sphaeropsis spores on the host. No such structures have ever been observed in the organism studied by the writer.

CORNELL UNIVERSITY

ITHACA, N. Y.

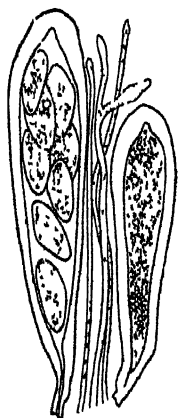


FIG. 2. Asci and paraphyses. *Cambrallucida* drawing.

¹⁰ Winter, G., *Die Pilze*. Rabenhorst's Krypt-Flora 2: 410. 1887.

¹¹ Ellis, J. B. and Everhart, B. M., *North American Pyrenomycetes*. p. 517. 1902.

¹² Saccardo, P. A., *Sylloge Fungorum* 13: 873. 1898.

THE RELATIVE PREVALENCE OF PYCNOSPORES AND ASCOSPORES OF THE CHESTNUT BLIGHT FUNGUS DURING THE WINTER¹

F. D. HEALD AND M. W. GARDNER

WITH PLATES XXVI, XXVII AND XXVIII

INTRODUCTION

In studying the dissemination of the chestnut blight fungus we have endeavored to determine the relative importance of pycnospores and ascospores in the spread of the disease. Since the pycnospores had generally been designated as "summer spores," and the idea had been rather generally prevalent that they were abundant only at the seasons of the year when "spore horns" were evident, it seemed desirable to determine by some careful analyses the extent to which they were produced during the winter months, when "spore horns" were entirely absent or but rarely found.

The common idea concerning the two types of spores is expressed in the following statement from Murrill:²

"Later the fruiting pustules push up through the lenticels and give the bark a rough warty appearance; and from these numerous yellowish-brown pustules, millions of minute summer spores emerge from day to day in elongated reddish brown masses, etc. In late autumn the winter spores are formed, which are disseminated from the dead branches the following spring."

Hodson³ states, "The yellow fruiting bodies so common on the diseased trees are constantly giving off millions of summer spores all through the growing season." The natural inference from this statement would be that the summer spores are not prevalent during the periods unfavorable to growth.

Referring to the production of ascospores, Mickleborough⁴ states, "In this way the fungus tides over the winter," and then follows a mention of the "summer spores or conidial spores" to be found in early spring and during the summer.

¹ Investigations conducted in coöperation with the Pennsylvania Chestnut Tree Blight Commission.

² Murrill, W. A. *Journal New York Botanical Garden* 7: 146. 1906.

³ Hodson, E. R. Extent and importance of the chestnut bark disease. Circular (unnumbered) U. S. Dept. Agr. Forest Service, p. 5. 1908.

PYENOSPORE TRAPS

In this work we have used what we have designated as a pyenospore trap, to catch and retain at least a part of the pyenospores washed down from a blight lesion during a rain. These traps were also designed to catch other spores, but they were designated as "pyenospore traps" since we have used an entirely different form of trap, the "ascospore trap," for detecting the expulsion of ascospores. The trap (pl. XXVI) consisted of a brass curtain screw (s) turned into the bark or trunk of the branch so as to stand at right angles to the surface; a glass object slide (o) set into a transverse groove in the bark and held by the screw at an angle of about 45 degrees; and a more or less compact mass of absorbent cotton (c) between the lower end of the slide and the vertical arm of the screw. The trap was always set below a lesion bearing fruiting pustules (l), in such a position that a part of the rain water flowing over the lesion would be conducted down the object slide and through the absorbent cotton (pl. XXVII and XXVIII). Traps were set at two different localities: 6 at West Chester, Pa. and 8 at Martie Forge, Pa. Those located at West Chester were set during a rain, and were so placed as to intercept a noticeable stream. Those at Martie Forge were not set during a rain and consequently were not as favorably located.

METHOD OF MAKING AN ANALYSIS

After each rain period the cotton from each trap was removed and placed in a sterile Petri dish for transport to the laboratory at the University of Pennsylvania where the analyses were completed. A new mass of cotton was put into place to be ready for the next rain. The cotton of each trap was introduced by means of sterile forceps into an Erlenmeyer flask containing 100 cc. of sterile water. Each flask was then shaken vigorously so as to set free all or as many as possible of the contained spores. In the earlier analyses 1 cc. or a fractional part of 1 cc. of the wash-water was placed in each Petri dish and the melted medium added, but the plates were always so heavily seeded with bacteria and rapid growing fungi that the much slower growing colonies of the blight fungus were completely overrun before they were large enough to count. It soon became evident that a much greater dilution would be necessary in order to lessen the number of rapid growing forms in each plate and give a satisfactory separation of the spores of the blight fungus. In all of the later work 1 cc. of the original wash-water was introduced by means of a sterile 1 cc. Mohr pipette into a second Erlenmeyer flask containing 99 cc. of the sterile water. The second

* Mickleborough, John. A report on chestnut tree blight. Pa. Dept. of Forestry, p. 10. 1909.

flask was shaken well and with another sterile pipette 1 cc. of this dilution or a fractional part, was introduced into the Petri dish to be used in making the culture. This method is illustrated in pl. XXVI, and it may be noted that the number of colonies of the blight fungus appearing in the culture represents 1/10000 of the total number of viable spores retained by the cotton. In many cases it was necessary to use even a fractional part of a cubic centimeter from the second flask in order to secure a sufficiently small number of spores of the blight fungus to give a reliable count.

The water containing the spores was always introduced into the sterile Petri dishes, and the melted medium cooled to 42° to 45°C, poured the same as in making a bacteriological analysis of water. Three per cent dextrose agar, plus 10, was employed in all of the analyses. The plates were incubated as nearly as possible at 25°C and the colonies suspected of being blight were marked at the end of four days. Their later development was then followed to substantiate the diagnosis. It was possible to determine by the time of appearance of the colonies that they originated from pycnospores rather than ascospores. This method is described in detail elsewhere.⁵

THE TRAPS AT WEST CHESTER

The pycnospore traps at West Chester were set on trees 4 to 8 inches in diameter, in a badly diseased coppice growth of native chestnut. Trees were selected so as to give varying conditions of the lesions, but perithecia were present in different stages of development from young to mature ones in the lesions located above the traps (pl. XXVII). Pycnidial pustules were, however, more abundant than the perithecial pustules. Additional facts recorded are given in table I.

ANALYSES BASED ON TRAPS AT WEST CHESTER

The pycnospore traps were set at West Chester, January 8, 1913, but satisfactory analyses were not obtained until the rain of January 17. Weather instruments were installed near the grove in a standard U. S. Weather Bureau instrument shelter. A Friez standard rain gage and a Friez thermograph were employed. The results of analyses of the traps at West Chester are given in table II.

THE TRAPS AT MARTIC FORGE

The pycnospore traps at Martic Forge were set on Paragon chestnut trees 5 to 13 inches in diameter, that had been grafted on native stock.

⁵ *Mycologia* 5: 274-277. September, 1913.

TABLE I
Traps at West Chester

	NUMBERS OF TRAPS					
	I	II	III	IV	V	VI
Orientation	SW	S	S	SE	S	S
Height from ground . .	3 ft.	1½ ft.	3½ ft.	1 ft.	2 ft.	1 ft.
Diameter of trunk at trap	1 in.	7 in.	6 in.	5 in.	7 in.	5 in.
Condition of branch or trunk above lesion	Dead	Dead	Alive, many dead limbs	Alive, few dead limbs	Dead	Alive, few dead limbs
Lesions above trap.....	Infection general	Infection general	Many	2 large ones on trunk 3 at base of branches	Infection general	Many. 6 large on main trunk. Many others on limbs (fig. 2)

The cankers above the traps were from one to three years old and showed the fruiting pustules in various stages of development. There were many mature perithecial pustules as well as an abundance of pyrenidial pustules. The perithecia were more abundant than in the lesions tested by the traps at West Chester. Additional facts recorded for each trap are given in table IV.

ANALYSES BASED ON TRAPS AT MARTIC FORGE⁶

The pycnospore traps were set at Martie Forge, Pa., January 28, 1913, but satisfactory analyses were not obtained until the rain of February 12. A set of weather instruments similar to those used at West Chester was installed in the orchard. The results of the analyses of the Martie Forge traps are given in table V.

THE EFFECTIVENESS OF THE COTTON TRAPS

The cotton of the traps was collected as soon as possible after the rain in order to lessen any possible loss from desiccation. In some cases the cotton was frozen when collected, as the winter rains were not infrequently

⁶ The field work at Martie Forge was done by Mr. C. E. Taylor, formerly in the employ of the Pennsylvania Chestnut Tree Blight Commission. He also assisted in making the analyses.

TABLE II
Summary of pycnospore trap records, West Chester, Pa.

DATE COLLECTED 1915	RAIN FALL REPRESENTED	TRAP NUMBERS AND NUMBER OF VIABLE PYCNOSPORES OBTAINED					
		I	II	III	IV	V	VI
		<i>inches</i>					
1/9	0.29						
1/11	0.13					45,000	1 750,000
1/15	0.24					Present	351,000
1/17	0.51						
1/20	0.31		Present	925,000	999,000		
1/29	0.24	12,950,000	Present	1,920,000	426,000	15,120,000	2,625,000
1/29	0.88	17,325,000	6,440,000	6,890,000	1,170,000	77,220,000	18,975,000
2/12	0.15	66,255,000		9,700,000	85,550	20,900,000	923,500
2/22	0.19	12,900,000	29,700,000	57,015,000	6,030,000	737,500	31,450,000
2/24	0.07	92,235,000	1,720,000	10,560,000	590,000	40,000	11 231,000
2/28	0.78	351,640,000	12,000,000	6,550,000	1,095,000	4,155,000	5,030,000
3/10	0.03	37,345,000	1,110,000	10,000		1,170,000	10,000
3/11	0.53	54,310,000	10,300,000	87,650,000	5,900,000	68,770,000	103,410,000
3/15	1.15	5,425,000		2,325,000	1,850,000	4,965,000	3 000,000
3/17	0.195	590,000	80,000	730,000	150,000	1,101,000	200,000
3/21	1.64	21,760,000	Present	4,600,000	9,100,000	26,400,000	37,700,000
3/28	1.15	18,710,000	18,900,000	8,800,000	5,200,000	21,750,000	22,540,000
3 31	0.05	100,000		28,980,000	101,000,000	580,000	18,560,000
4 5	0.56	49,770,000		97,650,000	38,430,000	129,280,000	57 120,000
4 14	2.49	540,000		1,855,000	315,000	246,000	1,680,000
4 17	1.57		3 152,000	516,000	106,000	1,488,000	3,925,000
4 28	2.43	936,000	180,000	176,000	510,000		704,000
4 30	0.11	32,590,000	86,000	52,480,000	470,000	756,000	1,575,000

TABLE III

Temperature records at West Chester, Pa. January, February, March, April, 1913

JANUARY			FEBRUARY		MARCH		APRIL	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	50	34	37	16	48	34.5	55	39
2	52	30	29	11	41	23	58	38
3	58	37	31	24	45	19.5	70	41.5
4	39	27	30	19	58	35	76	44
5	38	30	24	15	45	28.5	64	41
6	55	32	23	7	45	16.5	43	32
7	57	50	24	5	21	12.5	45	30
8	60	36	32	15	34	10.5	49	28
9	38	18	31	14	64	31	53	33
10	40	22	21	11	49	37	47	27
11	54	35	35	17	48.5	36	58	39.5
12	59	32	34	11	54	29	58	53
13	34	20	24	7	54.5	34	57	51
14	40	26	36	7	61	52	55.5	51
15	45	26	45	17	65	55	54	47
16	46	37	50.5	21	62	30	52	42
17	61	43	31	26	37	24	67	41
18	57	48	34	17	49	30	68	34
19	49	33	22	21	63	27	67	43
20	54	33	50.5	25	63	19	50	33
21	60	29	58	40	73	53	57	29
22	41	22	58	45	58	31	60	30
23	44	28	45	22	49	26	72	44
24	45	36	31	21	69	17	78	53
25	48	30	28	15	75	61	78	49.5
26	55	26	38	15	69	58	73	49
27	43	27	60	38	68	30	62	51
28	35	20	62	40	42	26.5	59	48
29	31	22			49	22	56	49
30	47	24			57	30	66	43
31	57	38			70	42		

followed by freezing temperatures. We have proved by experiments that freezing has little effect upon the viability of pycnospores in water.

When this device for collecting the spores was selected it was not with the idea that the cotton would retain all of the spores in the rain water passing through, but simply that the mass of cotton would hold a certain amount of rain water bearing spores in suspension. The numbers given in the analyses bear no relation to the amount of rainfall and represent only a small part of the number actually washed through the traps.

During the rain of March 15, some of the water flowing into traps one and three at West Chester was collected and the number of pycnospores

TABLE IV

Traps at Martic Forge

	NUMBERS OF TRAPS							
	I	II	III	IV	V	VI	VII	VIII
Orientation.....	NE	SE	W	W	SE	W	SE	NE
Height from ground	2.5 ft.	1.5 ft.	3.5 ft.	3 ft.	2 ft.	5 ft.	5.5 ft.	3.5 ft.
Diameter of trunk at trap..	6.5 in.	5.5 in.	7 in.	5 in.	7 in.	7 in.	6 in.	6.5 in.
Condition of branch or trunk above lesion....	Dead	Alive, but nearly girdled	Dead	Dead except one 2.5 inches branch	Dead	Alive, Only little infected	Alive, but three-fourths girdled	Alive, but badly discolored.
Lesions above trap....	Infection general for 2 feet above	One 12 x 14 inches just above; two others higher up not in line with trap	One nearly girdling trunk just above trap; three higher	One 10 x 9 inches just above. Another few in. higher on same side; two others higher	One just above completely girdling trunk. Pustules general for 3.5 feet above trap	One lesion 8 feet from trap	One lesion 9 x 9 inches just above	One lesion 1.5 x 16 inches just above trap. One other 1 foot higher but lateral.

TABLE V
Summary of pycnospore trap records, Martie Forge, Pa.

DATE COLLECTED 1913	RAINFALL REPRESENTED inches	TRAP NUMBERS AND NUMBER OF VIABLE PYCNOSPORES OBTAINED							
		I	II	III	IV	V	VI	VII	VIII
2 4	0.06	190,000	110,000	60,000	30,000		120,000		70,000
2 12	0.03							2,870,000	385,000
2 24	0.09	55,000	199,500	235,000	995,000	2,910,000	145,000	290,000	10,000
2 28	0.36		150,000	870,000		280,000	130,000	120,000	
3 6	0.02			30,000					
3 11	0.55		1,310,000	475,000	20,000		635,000	640,000	150,000
3 14	1.29		285,000	3,030,000	10,000			210,000	55,000
3 17	0.92	1,460,000	355,000	575,000	230,000	125,000		235,000	30,000
3 21	0.62	100,000	470,000	500,000		1,130,000	40,000	1,030,000	
3 28	3.47		900,000	1,510,000	1,160,000	190,000	30,000	560,000	50,000
4 3	0.14		5,230,000		170,000	13,900,000	1,180,000		70,000
4 7	0.23			3,550,000	0,000			3,650,000	
4 11	0.55	100,000	10,000	14,270,000		450,000	880,000	1,090,000	50,000
4 15	1.23			16,650,000	505,000	155,000		170,000	90,000
4 17	1.15	10,000	59,000	50,000	86,000	59,000		146,000	
4 30	2.40	174,000	850,000	5,435,000	1,590,000	408,000		944,000	674,000

TABLE VI

Temperature records at Martie Forge, Pa., February, March, April, 1913

	Max.	Min.	Max.	Min.	Max.	Min.
1	12	21	16.5	30	51	10
2	37	17	10	19	58	12
3	37	32	19	19	71	39.5
4	36	27	61	13	80	51
5	32	23	14.5	30.5	59	10
6	27	16	13	17	12	32
7	31	12	21	12	19	33
8	39	24	35	9.5	52	27
9	38.5	19.5	66	35	55	31.5
10	30	17.5	52	11	50	31
11	42	23		38	57	41.5
12	39	11.5	16	27	58	51
13	30.5	10	55	46	57	51
14	41.5	12.5	67	53	58	51
15	51	25	61	53	55	49
16	57	31	53	31	59	45
17	39	29	38	32.5	60	40
18	36	18.5	51	21	72	42.5
19	45.5	21.5	65	35	68	43
20	57	20.5	66	49	54	35
21	59	45	68	55	59	33
22	56	48.5	59	29	77	37
23	48	24	55	25.5	77	19
24	30	19	71	50	83	52.5
25	38.5	15	78	61	81	57
26	38.5	13.5	69	58	80	55
27	58	38.5	65	29	66	19
28	61	37	43	24	62	15
29			51	20	51	16
30			59	38.5	67	35
31			60	44		

per cubic centimeter determined. The water from trap 1 yielded 302,100 and trap 3 gave 131,000 per cubic centimeter. The cotton of the trap would hold 15 to 20 cc. of water when saturated. The analysis for trap 1 on this date showed 5,425,000 spores or the number that would have been in suspension in 17.94 cc. A test made in the laboratory would also substantiate these results. 94,871,500 pycnospores were passed into a cotton trap and only 2.9 per cent were retained by the filtering action alone. We must conclude then that the figures given in the tables are but a meager expression of the vast number of pycnospores washed down from the cankers with each rain.

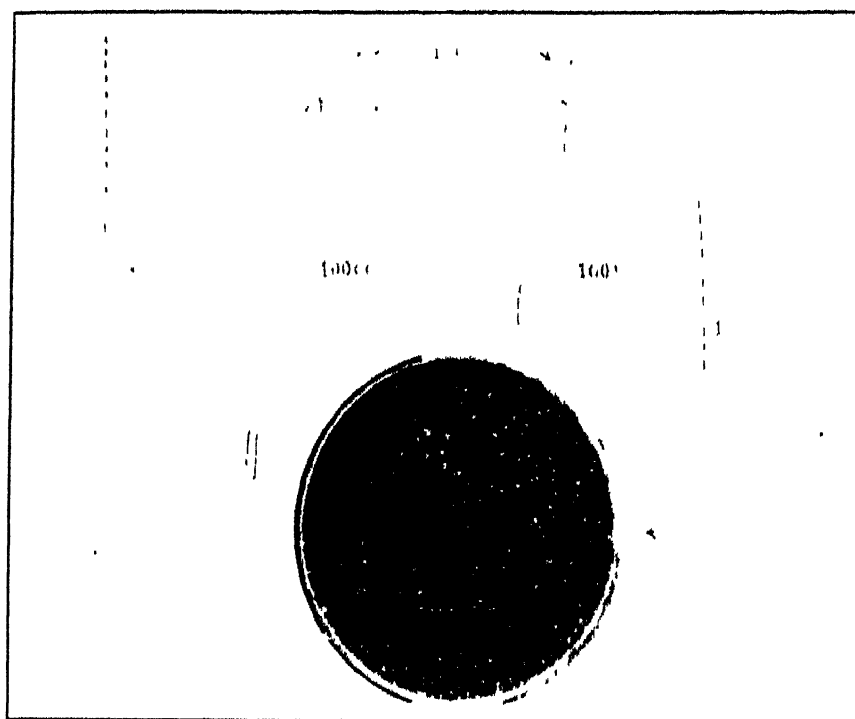


PLATE XXVI. A SPORE TRAP

The diagram shows a pycnospore trap and the method of making an analysis. (*s*), brass curtain screw; (*o*), object slide with arrow indicating the downward flow of rainwater; (*c*), mass of absorbent cotton; (*l*), lesion in bark of tree. The plate culture shown is one of the West Chester series and shows but few foreign colonies.

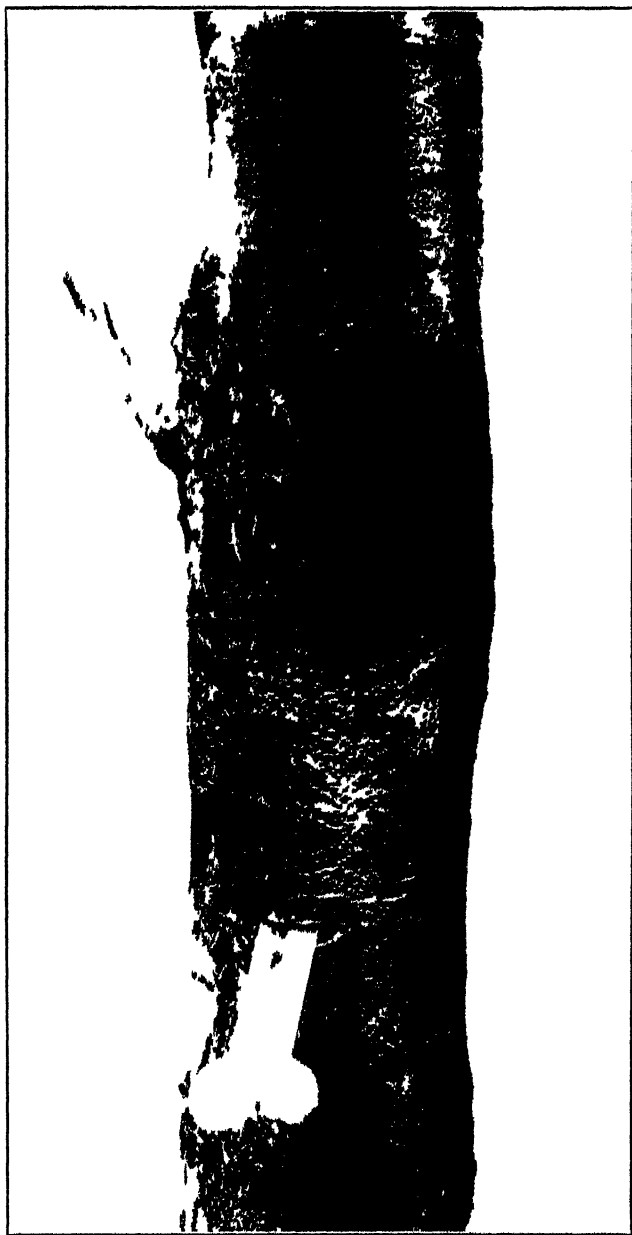


PLATE XXVII. A STORE TREE

Pycnospora trip No. 6 at West Chester showing relation to large lesion immediately above it

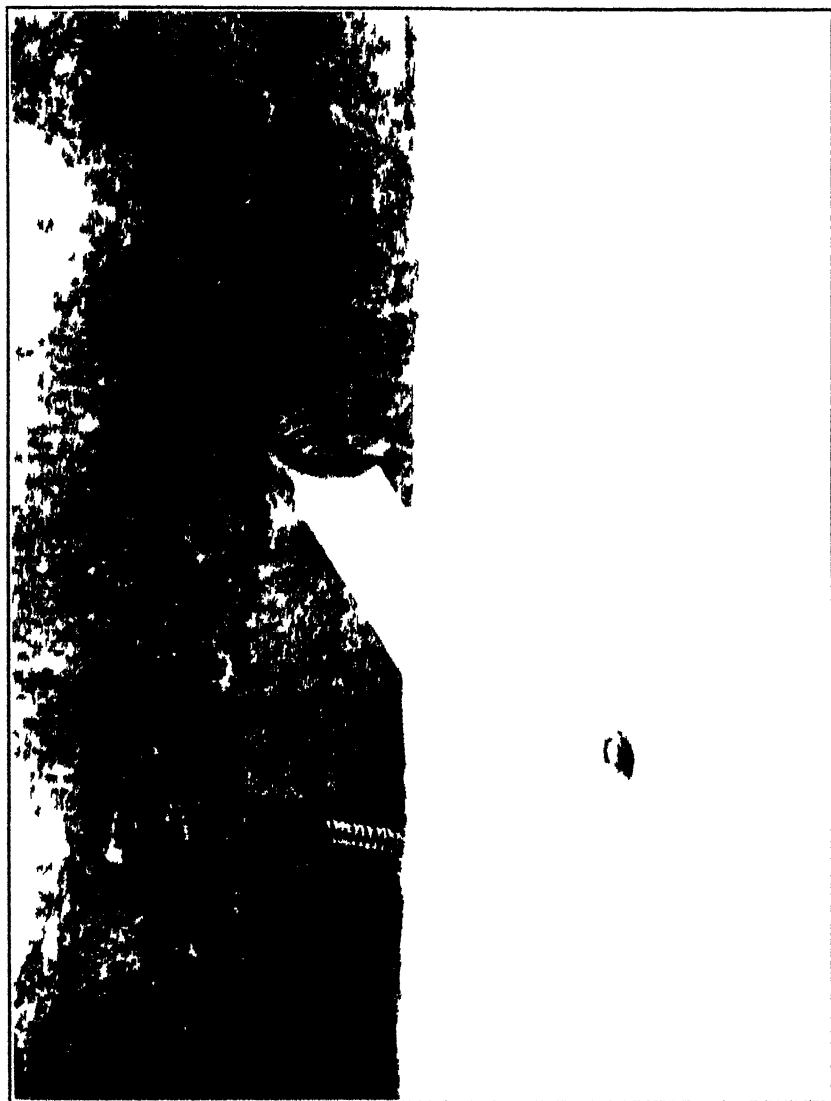


PLATE XXVIII — A STONE TRAP
Pycnosporic trap No. 6 — at West Chester — Side view, nearly natural size

MICROSCOPIC EXAMINATION OF CENTRIFUGED SEDIMENTS

A portion of the water in which the cotton was washed was always centrifuged to throw down any spores which might be present, and the sediment was retained for microscopic examination. In case the microscopic examination was not made at once, the centrifuged sediment was preserved by the addition of formalin. The microscopic examinations involved a large amount of work, but it was thought best to employ this as a check to the results obtained by the plate cultures. Whenever the plate cultures showed the presence of the blight fungus, pycnospores could always be found in the centrifuged sediments, but *ascospores were uniformly absent*. This substantiates the results obtained by the plate cultures, as none gave an indication of colonies which originated from ascospores. The spores of various other fungi were present in the sediment, but no general attempt was made to identify them. A species of *Coryneum*, probably the conidial stage of *Melanconis madonia*, was found at all times during the period covered by the analyses.

CONCLUSIONS

The analyses from the traps at both West Chester and Martie Forge show that viable pycnospores of the chestnut blight fungus were washed down the trees in enormous numbers during every winter rain. This was at a time when visible "spore horns" were absent or but rarely produced. These results are somewhat contrary to the generally accepted view, since pycnospores have generally been designated as "summer spores." It may be noted that the past winter was one of unusual mildness, but taking even this into consideration the results obtained point to the conclusion that pycnospores are prevalent throughout the entire year, and that the production of "spore horns" is but a visible index of their maximum production.

The analyses also show that ascospores were not washed down by the rains during the period covered by the tests. Detailed observations of field ascospore traps, to be published later in full, have shown that expulsion of ascospores is dependent upon temperature as well as moisture. There was no expulsion of ascospores under field conditions from late November until the rain of March 21, when temperature conditions were favorable. Ascospores were not expelled during the warm winter rains, and were not obtained in the traps for the few times when expulsion did take place.

FOREST PATHOLOGY LABORATORY
UNIVERSITY OF PENNSYLVANIA
PHILADELPHIA, PA.

THE INTRODUCTION OF A EUROPEAN PINE RUST INTO WISCONSIN

J. J. DAVIS

In September, 1912, Mr. J. G. Sanders, Entomologist of the Wisconsin Agricultural Experiment Station, while in performance of his duties as Nursery Inspector, observed a great abundance of rust on a certain weed at a locality near Sturgeon Bay, Wisconsin. Because of the abundance of the rust, he plucked a specimen and submitted it to the department of plant pathology of the University. In November, 1912, Mr. Sanders, at my request, wrote for additional material which was kindly sent, bearing then the telial as well as the uredinial stage. This additional material made possible the identification of the host as *Sonchus asper* (L.) Hill and the rust as *Coleosporium sonchi-arvensis* (Pers.) Lev. As this European rust had not been previously reported as occurring in America, I visited the locality in June, 1913, to see if it was permanently established. The host of the Peridermium of this species in Europe is *Pinus sylvestris* L. This pine I found about the grounds as an ornamental and shade tree and also in an old nursery plantation. All of these trees bore the peridermial stage of the rust, many of them in profusion. A single tree of *Pinus strobus* L. was found upon the premises and upon this no Peridermium was seen. About half a mile distant, in a seed bed of *Pinus banksiana* Lamb., a single leaf was found bearing a Peridermium, but it has not been determined as yet that it is of this species. As the Jack pine, like the Scotch pine is twin leaved, it may be that the rust would attack it also and the native red pine as well.

The mode of introduction and establishment of this rust seems to have been as follows: Five or six years ago an importation of Norway spruce was made and the trees were unpacked along side of the Scotch pine plantation. Doubtless in or with the packing of these young spruce were rusty leaves or fragments of leaves of sow thistle. If so, the teliospores doubtless germinated in the spring and the *Pinus sylvestris* was at hand to bear the Peridermium. Not far away was a wood pile which had gradually migrated toward the house leaving in its wake a soil composed largely of well rotted chips. Here was a flourishing bed of sow thistle which received the peridermial spores and made possible the completion of the life cycle of the rust. A few rods distant was a house surrounded by

Scotch pines and with sow thistles in the garden so that another station was added to the initial one. As the *Peridermium* of this rust is annual it does no damage except the destruction of a certain amount of leaf tissue, and the disease can be readily eradicated by destroying all *Sonchus* plants in the vicinity. However, the introduction and the establishment of this foreign rust shows clearly that all packing and refuse that accompany imported plants should be thoroughly destroyed, as even small fragments of leaves may introduce disease-producing organisms.

UNIVERSITY OF WISCONSIN HERBARIUM

NOTES ON CRONARTIUM COMPTONIAE, II¹

PERLEY SPAULDING

In a previous note the writer² gave some data concerning the eastern pitch pine blister rust caused by the fungus *Cronartium comptoniae*. Since that time it has become evident that this fungus is of considerable economic importance, a fact, which was not realized when the writer's investigations were begun. Its supposed harmlessness was due to the fact that the native host pines, *Pinus rigida*, *P. virginiana*, and *P. divaricata* (which is probably also a host), are ordinarily of little value as timber trees, and while it was known that a number of young trees died from its effects they were considered to be of practically no value. Reports received by the writer, and personal observations, have shown that it causes a serious nursery disease upon several species of the pitch pines. *P. ponderosa* seems to be especially susceptible. Specimens on this host were received from two localities in Massachusetts, and it was noted by the writer in one Connecticut locality. In the latter, approximately 10 per cent of the total stand (about five years of age) bore fruiting bodies of this fungus. The fungus from the two Massachusetts localities was successfully inoculated onto *Comptonia asplenifolia*, by the writer in one case and by Dr. G. G. Hedgecock in the other, confirming previous transfers between these hosts by Clinton³ and the writer.⁴ There is little doubt that this fungus will be a serious enemy of *Pinus ponderosa* in the eastern states should that pine ever be grown in any quantity here in seed beds. *P. sylvestris* was reported by Clinton⁵ in 1908 as a host for this fungus and successful inoculations were made by him upon leaves of *Comptonia asplenifolia*. In 1912, it was received by the writer from a Massachusetts locality and successful inoculations were made upon *C. asplenifolia*.⁶ This season it was received from another Massachusetts locality, and successfully cross inoculated. No case has yet been seen where any considerable number of trees of *Pinus sylvestris* was affected, but the above cases show there is some danger to this host species under conditions favorable

¹ Published by permission of the Secretary of Agriculture.

² Spaulding, Perley, Notes on *Cronartium comptoniae*. *Phytopathology*. 1: 62 1913.

³ Clinton, G. P., Report of the botanist. Conn. Agr. Expt. Sta. Rept., 1907-1908: 380-383. 1908.

⁴ Spaulding, Perley, loc. cit.

⁵ Clinton, G. P., loc. cit.

⁶ Spaulding, Perley, loc. cit.

to the fungus. It should be remarked, however, that the evidence indicates that the heavy infections of all the pines take place while the trees are three years old or younger. This is shown by the position of the fungus at or below the first whorl of branches in most cases, and by the fact that careful search has thus far failed to reveal any infection in a large lot of healthy *P. sylvestris* trees which have been set out for a number of years where the fungus is present in abundance upon both *Comptonia asplenifolia* and *Pinus rigida*. It is not uncommon to find trees which have the rust located higher in the main stem or out on the branches, but such cases make but a small percentage of the total number of affected trees. At least, this is the writer's experience to date in observations made during the past five years, throughout the region north and east of Washington, D. C. This fungus has appeared also as a threatening enemy of young trees of two other pitch pines: i.e., *Pinus taeda* and *P. echinata*. The former is being successfully grown in New Jersey considerably north of its natural range, but has been found to be attacked in the nursery by *Cronartium comptoniae*. Specimens of diseased *Pinus taeda* were received by the writer and successful inoculations made by him in the greenhouse with the spores upon *Comptonia asplenifolia*. A specimen of young *Pinus echinata* affected by this fungus was received in 1908 from Biltmore, North Carolina, with the information that it was common on seedlings of this host which were being raised there for forestry planting. Thus we see that within a few years this fungus has been found affecting four different species of the more valuable timber pines in nurseries. It is also known to occur upon *Pinus austriaca* and *P. virginiana* occasionally, and specimens on these hosts are in the writer's hands, the former from a Massachusetts locality and the latter from a Maryland locality. Spores from *P. austriaca* have been successfully inoculated onto *Comptonia asplenifolia* by the writer.

Pinus rigida seems to be the favorite native host pine for this fungus, however. In a previous paper⁷ the writer stated that a mortality for a single year from this disease of over 5 per cent of the diseased trees was observed in a lot of natural reproduction of this species. The trees were mostly less than 10 feet in height, but some were taller than this. This season a recount of the diseased trees of this area which bore fruiting bodies of the fungus was made. Someone had removed a number of the metal tags placed upon the diseased trees last year, but sixty-six out of the one-hundred and forty-seven were found still bearing the tags and sixty-three of those from which the tags had been removed were retagged. The remainder were scattered away from the main body and were not hunted up, it being thought best to work with a compact body of trees. Of the sixty-

⁷ Spaulding, Perley, loc. cit.

six trees still bearing tags, and which last year bore fruiting bodies, sixty-three also bore them this year. The three which had no fruiting bodies this year were covered toward the base with pitch which had exuded through the crevices in the bark. This seems to be quite characteristic for trees of this species when dying from the effects of this disease. In the area occupied by the one hundred and twenty-nine diseased trees which were counted, a total of ten trees was found recently dead. These, in the writer's judgment bore evidences of dying from the attacks of this fungus. Indeed, four of them bore tags placed on them last year, showing that they bore fruiting bodies then. The writer is quite sure the remainder also had tags, but that they had been removed. In these counts no tree is counted as dead until the leaves have all died. Several were noted which will die shortly, but their leaves are still green and they were not counted. The above figures show a mortality for 1913 of 7.8 per cent and one of nearly 13 per cent of the total number of diseased trees for the two years that records have been kept. Such a loss as this with a valuable species of pine would ordinarily be considered serious³ especially where this rate of loss will apparently be continued for a considerable number of years. Ordinarily trees of *Pinus rigida* do not show this disease or the fruiting bodies of the fungus after they attain a diameter of about 4 inches, which occurs at about the age of twenty years. In fact it is a rarity to find a tree of this size bearing fruiting bodies of the fungus. A single tree was found this season, however, which was fully six inches in diameter and which had fruiting bodies on the thin bark of a partially healed wound, and none anywhere else, although there was some evidence of the disease having been present lower down on the stem and of its having extended up to the wound. Apparently the bark becomes so thick on older trees that the fungus cannot push forth its fruiting bodies, as the fruiting bodies on older trees are always located in the crevices where the bark is thinnest. It is believed that most of the diseased trees die before they reach this stage, but there are apparently a few which continue to live with the fungus present. It seems entirely possible for occasional diseased trees to reach such an age that the bark is too heavy for the fungus to push forth its fruiting bodies.

The numerous above mentioned specimens of this fungus from Massachusetts do not indicate that there is any more of this disease there than in other states, but that more material has been available for study from Massachusetts.

U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

" "

³ Clinton G. P., Report of the botanist, 1909 and 1910. Conn. Agr. Expt. Sta. Rept. 1909-1910: 733. 1911.

PHYTOPATHOLOGICAL NOTES

Another host for Rhodochytrium. Since the discovery several years ago of *Rhodochytrium spilanthis* Lagerh. on the ragweed in the United States, two notes have appeared relative to its distribution. The first of these by Atkinson¹ records its collection in fourteen localities in North Carolina, and the second by Hall,² in twelve places in South Carolina, two in Alabama and one in Maryland. The latter investigator is of the opinion that it may be found in Virginia and Georgia, thus connecting Alabama, the Carolinas and Maryland. It might be of interest to add that, during the past summer, it has been collected by Prof. J. S. Caldwell in the mountains of Eastern Tennessee and by the writer in two additional localities in Alabama, Montgomery and Fort Payne.

While making the collections near Montgomery, this algal parasite was found growing upon the leaves and stems of the giant ragweed, *Ambrosia trifida* L., which occurred together with the common ragweed *A. artemisiifolia* L. It has previously been reported only on three hosts, *Spilanthes* sp. in Ecuador, *Asclepias pumila* in Kansas, and on the common ragweed as noted above. Because of the close relationship of the two species of *Ambrosia* and the fact that parasitized plants of both species were growing side by side, there can be no doubt that the form on *A. trifida* is the same as the one on *A. artemisiifolia*. Material from this collection has been sent to Prof. G. F. Atkinson, Cornell University, and to Dr. R. F. Griggs, Ohio State University.

Since the giant ragweed is so widely distributed it seems highly probable that *Rhodochytrium* may be found upon it coextensive with this parasite upon the common ragweed. This note is published merely to direct the attention of collectors to another host while studying the distribution of this remarkable parasite.

FREDERICK A. WOLF

Note on Plowrightia morbosa. *Plowrightia morbosa* is universal in Iowa on all sorts of wild plums. I have never noticed it on *Prunus virginiana* or *P. pennsylvanica*; but about Lake Okoboji in the northwest corner of the state, black-knot occurs not only on all the wild plums, sometimes to the

¹ Science 28: 691-692. 1908.

² Science 36: 364. 1913.

extermination of a grove, but proceeds further and assails the thickets of June-berry, *Amelanchier canadensis*, and does immense damage.

On the wild plum the black-knot is frequently accompanied by *Fomes ignarius*, a saprophyte, no doubt, but in this instance as in many others that might be cited, I fancy the fungus is not always careful to wait the preparation of its banquet by secondary causes or agencies more remote. Instead, it sometimes becomes "particeps criminis," hastens by its presence, if in no other way, the fatal issue in the nobler plant, and kills the patient by the mere rattle of the undertaker's wagon. The subject of facultative parasitism today affords a wide field for investigation.

T. H. MACBRIDE

The International Institute of Agriculture in its fourth session at Rome, May 5 to 12, 1913, considered a proposal for an international agreement for the control of plant diseases, and unanimously adopted the following resolutions

"1. The general assembly recommends that the governments adhering to the Institute organize, if they have not already, a government service of phytopathology.

"2. The general assembly, recognizing the need of an international agreement on the means of controlling plant diseases, deems it essential that an international commission of experts be convened and expresses the wish that the French government continue the initiative it took in this matter by bringing about the holding of such an international commission as soon as possible and not later than May, 1914.

"3. The general assembly is of opinion that on the occasion of each session of the general assembly of the International Institute of Agriculture experts of the adhering governments should meet in a special commission to come to a mutual understanding on their common researches and studies on plant diseases.

"4. The general assembly calls on the adhering governments to initiate the study of the several questions to be brought before the international commission of phytopathology on the basis of data to be supplied by the International Institute of Agriculture."

A brief report of this meeting of the International Institute of Agriculture at Rome is available in Senate document 196, 63d Congress.

The French government has renewed its official invitation to the United States to participate in an International Conference of Phytopathology to be held at Rome, February 24, 1914. Under the existing law it will be necessary to secure authority from Congress to accept this invitation.

Personals. Mr. Fred D. Fromme, graduate of the South Dakota State College, and Mr. H. C. Travelbee, graduate of Purdue University, have become assistants in the botanical department of the Indiana Experiment Station, filling positions formerly occupied by Dr. F. D. Kern and Mr. J. B. Demaree, who have gone to Pennsylvania State College. Their chief work will be in connection with the rust problems under investigation by the department.

Dr. F. L. Stevens, recently Dean of the College of Agriculture, Mayaguez, Porto Rico, has been appointed to the newly established professorship of plant pathology in the department of botany of the University of Illinois. He will transfer his relations to Illinois, February 1.

Dr. Bascombe B. Higgins, recently a graduate student in Cornell, has been appointed botanist and plant pathologist in the Georgia Experiment Station.

Dr. W. Ralph Jones, recently scientific assistant in the office of fruit disease investigations in the Bureau of Plant Industry, has been appointed professor of biology in Emory College, Oxford, Ga. He is succeeded by Raymond B. Wilcox, lately a graduate student in plant pathology in the University of Wisconsin.

Dean H. Rose, sometime assistant in botany in the Kansas Agricultural College, and more recently a graduate student in the University of Chicago, has been appointed pathologist in the Missouri State Fruit Experiment Station at Mountain Grove, Mo.

Dr. C. E. Lewis has resigned his position as associate in plant pathology in the Maine Experiment Station, to enter private business.

John H. Parker, recently assistant in plant pathology in the College of Agriculture of the University of Minnesota, has been appointed scientific assistant in the office of cereal investigations of the Bureau of Plant Industry.

Geo. F. Miles has resigned his position as pathologist in the office of cotton and truck disease and sugar plant investigations in the Bureau of Plant Industry, and has assumed charge of the truck growing department of the Potter Palmer Company, Sarasota, Fla.

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